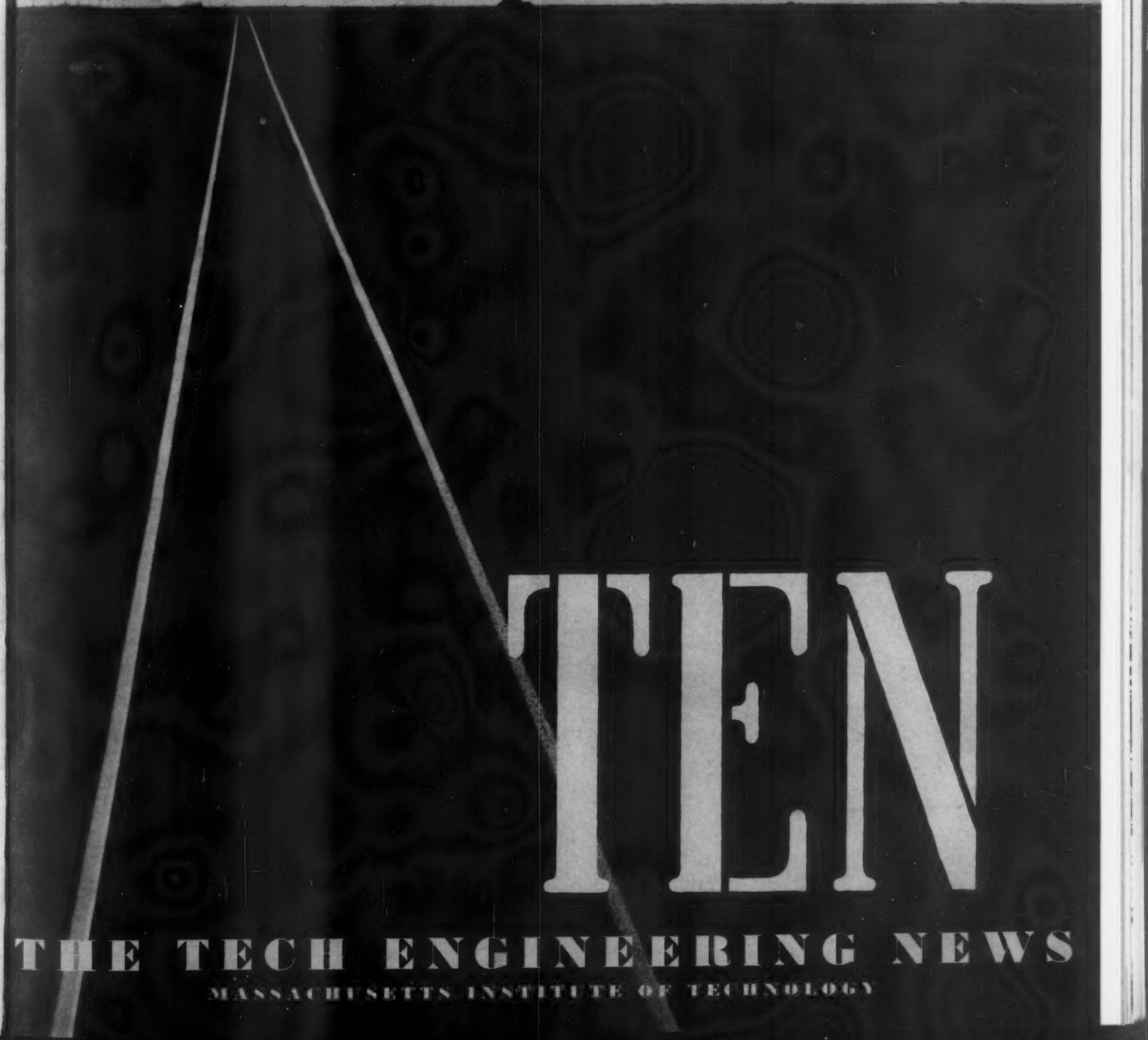
MAY · 1941



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THE TECH ENGINEERING NEWS

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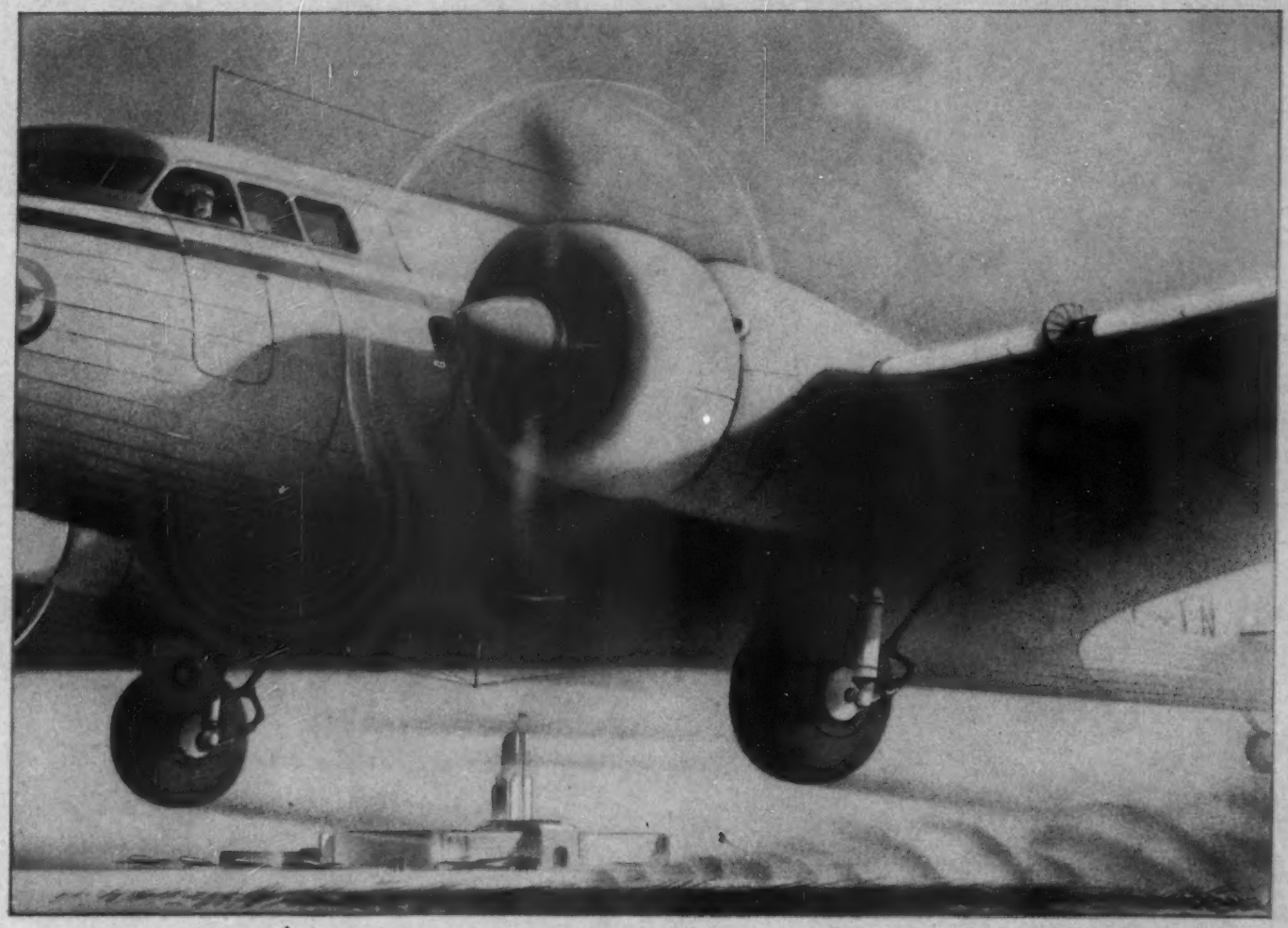

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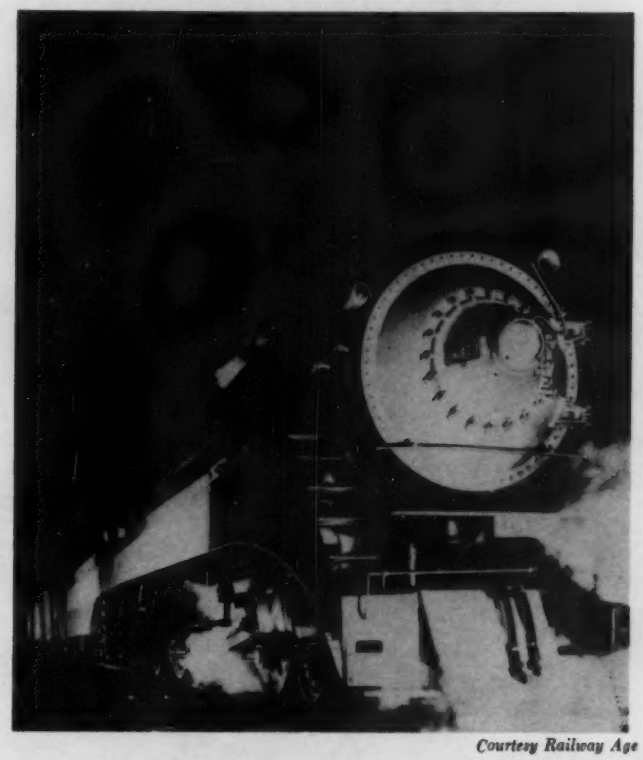

Courtesy Railway Age

VOLUME XXII NUMBER 4

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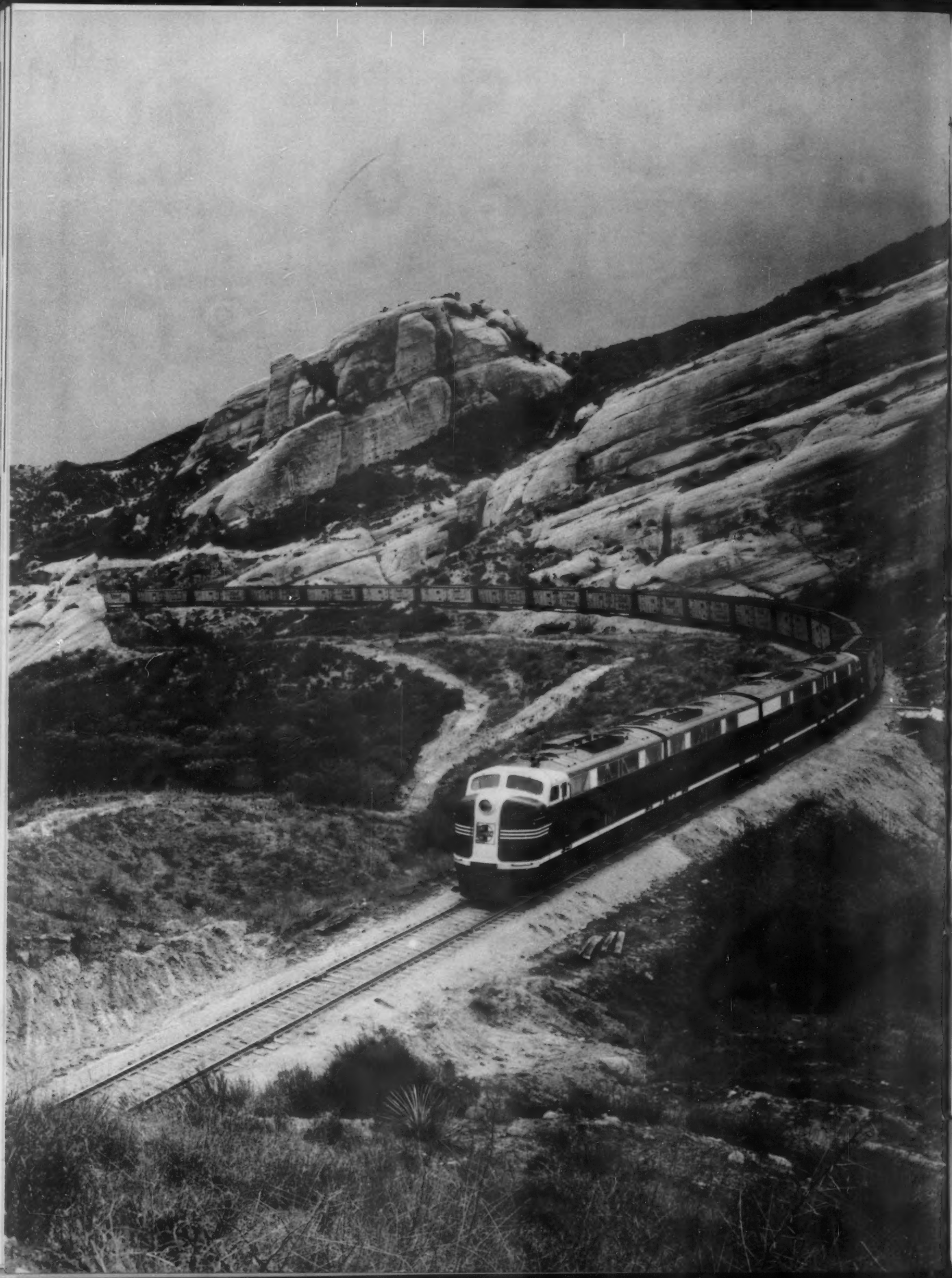


DIESELS ON WHEELS

POWERFUL UNITS ARE NOW COMBINED TO HAUL STRINGS OF 50 LOADED FREIGHTS OVER THREE PER CENT GRADES, AND AT 75 MPH ON THE LEVEL

By LEO FEUER, '43

THE word Diesel today popularly connotes rugged mechanical power. The word has had a peculiar fascination to the public ever since the inventor died a mysterious death over twenty years ago. At that time, it was predicted that the Diesel would soon replace the gasoline engine because of its relative simplicity and operating economy. The rise of this type of internal combustion engine was not quite as rapid, however, as had been predicted, mainly for the reason that many unforeseen difficulties arose. The engineers apparently were not as fond of it as the general public. Ten years ago the Diesels then in use were heavy, ponderous machines; they were solidly mounted and only a comparative few had wheels placed beneath them, almost none had been installed in airplanes. The United States and Germany were the only countries to spend large sums of money on Diesels. In Germany this was a matter of stark necessity because fuel oil was more readily available than the highly refined gasoline. In the United States the initiative was taken by private companies which felt that the Diesel would be an important addition to the existing sources of power.

The widespread adoption, during late years, of the Diesel internal combustion principle, has resulted in one of the foremost advancements in the development of railway motive power. By generating dependable and economical power in comparatively light-weight, serviceable units, the modern Diesel engine has contributed much toward the comfort and facility of train travel, and toward efficiency and economy in train operation.

The Santa Fe is the first railway to adapt Diesel-electric locomotives to all branches of railway transportation services. In passenger operation, Diesel locomotives power the Santa Fe's streamlined trains, the largest fleet in the world.

Diesel locomotives today are a symbol of speed and power, capable of operating continuously under varying climatic conditions, on fast schedules, and on long runs. The Santa Fe acquired its first Diesel-electric, a 600 horsepower four-stroke cycle switching locomotive in 1935. The next year two 1,800 horsepower two-stroke cycle locomotives were placed in transcontinental service on the Super Chief, Chicago to Los Angeles run. Since then twenty-three Diesel passenger locomotives and forty-three switchers have been put into service. The latest one is a 5,400 horsepower freight locomotive.

The Diesel principle as adapted to motive power closely follows the principles embodied in the discovery by Rudolph Diesel, the German engineer, born in Paris in 1858. Rudolph Diesel's experiments proved that the high compression of air drawn into a cylinder generated a degree of heat sufficient to explode the oil and powdered coal which he caused to be injected into the cylinder. That is the basic Diesel principle — the exploding or firing of combustible fuel, ignited by heat generated by compressing pure air in the Diesel engine cylinders. In a Diesel engine, only air is taken into the cylinder on the intake stroke. and fuel is introduced later and separately. The fuel is ignited because the air has been raised to the temperature of red hot iron by the compression. With the gasoline engine, fuel and air are mixed in the carburetor and this combustible mixture is taken into the cylinder on the intake stroke and is ignited by a spark from the ignition system. That comprises the major difference between a Diesel and a gasoline engine.

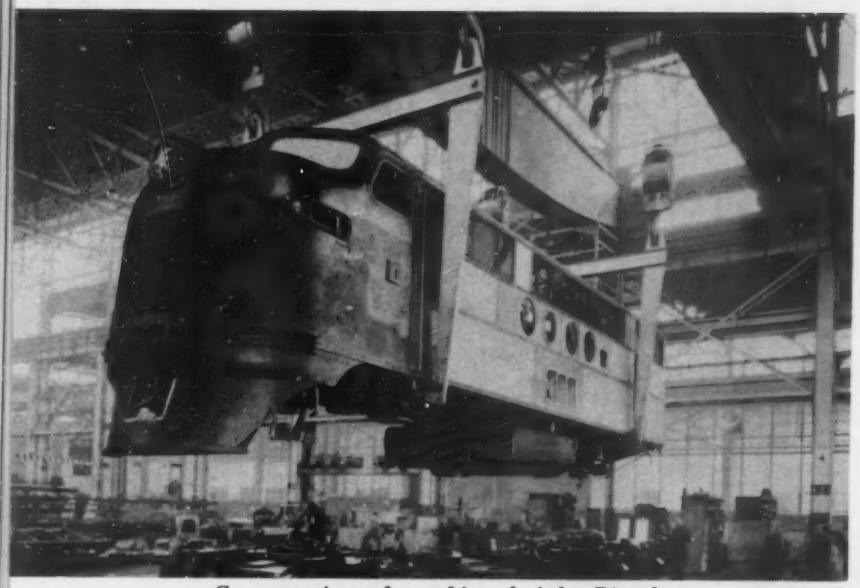
Besides being the first Diesel locomotive in regular mainline freight service and the first equipped with electric retarding brakes, the Santa Fe 5,400 horsepower Diesel Locomotive No. 100 is said to have greater tonnage-moving capacity than any steam locomotive ever placed on the rails, and the truth of this claim is apparently indicated by the accompanying table which compares it with the largest and most powerful steam locomotives previously built.

	Length Ft.	*Weight Lbs.*	*Starting Force Lbs.*
5,400-hp. Diesel locomotive (1940)..	193	923,600	220,000
N.P.2-8-8-4- simple steam (1929) ..	125	1,116,000	153,000
Virginian 2-10-10-2 compound (1918)	97	898,000	176,000
Erie 2-8-8-8-2 triplex (1914).....	90	853,000	160,000

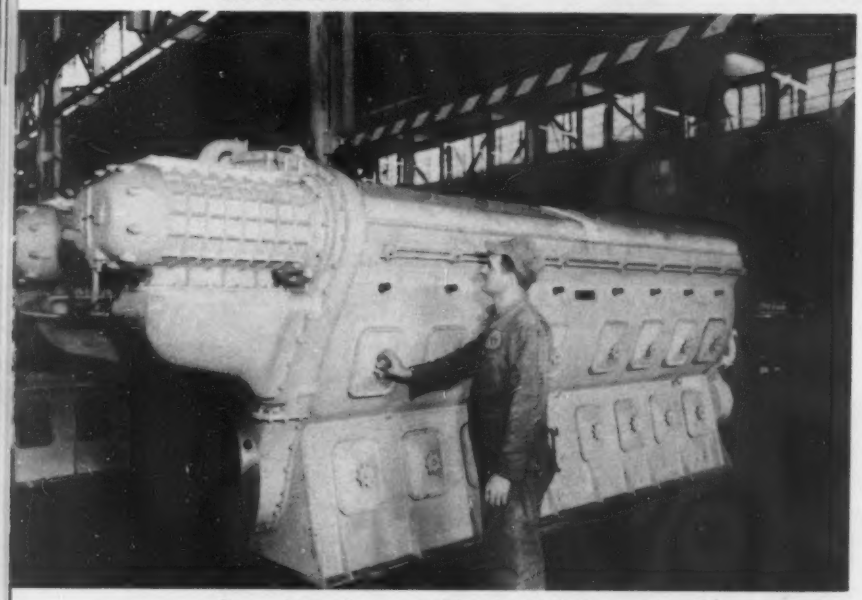
The Diesel locomotives are fueled with a fuel oil similar to the No. 2 fuel oil used in residential heating furnaces. The oil for Diesel use, however, must be free of sediment, with sulphur, carbon, ash, and water content held to a low figure. Cleanliness prevents expensive cylinder and ring wear, and permits proper injection of the oil into the cylinder.

When the pure air which has been drawn into the Diesel engine's cylinders has been compressed to approximately 650 pounds per square inch pressure, the temperature of the air is raised to approximately 1000° F., and a device known as the injector forces a small amount of fuel through a spray nozzle located in the cylinder. The nozzle has six small openings each about .010 inches in diameter. This results in fuel being atomized, throwing a fine oil fog into the cylinder. The high temperature of air in the cylinder ignites the fuel and the burning fuel expands, forcing the piston downward on the power stroke. In the four-stroke cycle engines, injection and explosion take place on the second upward stroke of the piston; in the two-stroke cycle, on every upward stroke of the piston.

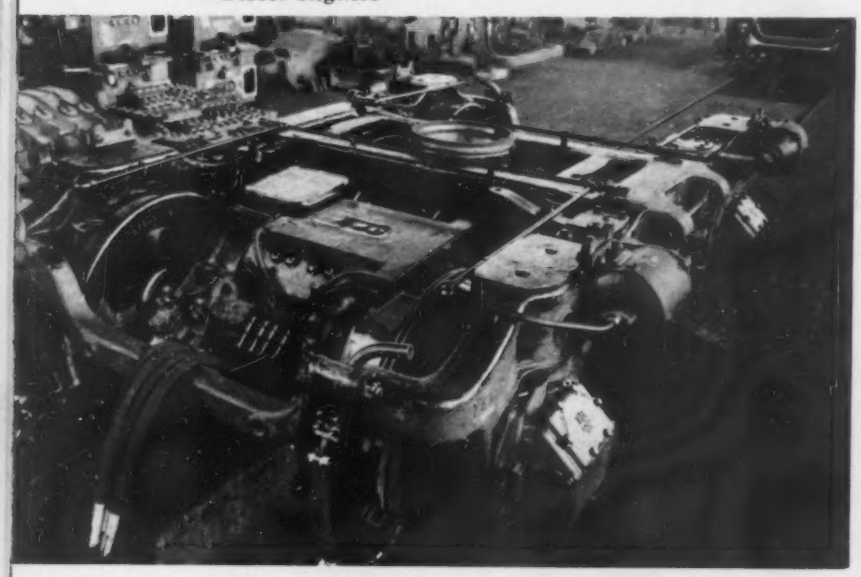
Each Diesel engine unit is coupled to an electric



Construction of trucking freight Diesel electric locomotive *Santa Fe*



One of the General Motors 1350 h.p., 16 cylinder, 2 cycle Diesel engines



One of the four-wheel power trucks ready for application under the locomotive

generator. These generators supply electric current to traction motors mounted on each pair of power wheels in trucks of each unit. The driving axles pull the locomotive and train.

The new 5,400 horsepower freight locomotive was designed and built by Electro-Motive Corporation, a General Motors subsidiary. Motive power is derived from four 1,350 horsepower, two cycle, 16 cylinder Diesel engines, one in each locomotive section. Each engine is directly connected to an EMC 600-volt d.c. generator and a two-stage, three-cylinder Gardner-Denver air compressor. A supplemental 10-kw. auxiliary generator, adjustable between 74 and 78 volts, is mounted above and driven by vee belts from each main generator. The generators are used as motors for engine starting. Each generator feeds four EMC Type D-7b d.c. roller-bearing motors, two in each truck assembly, directly geared to the driving axles. Motors are cooled by clean air delivered from blowers in the body immediately above the motors through ducts in the floor which connect with flexible rubber ducts held against the motor-housing air intake ports.

High-voltage control consists of manual transition forward and backward, with four motor connections, series-parallel, series-parallel-shunt, parallel, and parallel-shunt. Switch equipment for transmission of single generator output to four traction motors is suitably arranged in ventilated cabinets. All high-voltage circuits are safely guarded by a ground protective relay. There are two Exide 32-cell storage batteries, one in each end section.

The cooling system for the engines consists of two 200 gallons per minute engine-driven water pumps and forced air circulation through Harrison fin-tube radiators located in the ceiling of the engine rooms. Each engine has a separate water supply tank with cooling-system capacity of 225 gallons. Provision is made for steam jet preheating of cooling water from an external source after a layover period, if desired. Engine temperature control is accomplished by forced air circulation through seamless-tube type radiator assemblies. Four vertical 34-inch fans, driven from the engines through clutches, deliver approximately 80,000 cubic feet per minute of air per engine. The engine air delivery is completely controlled by means of the fan clutches and by the manually operated shutters mounted in the air intake ducts, located along the top of the locomotive sides.

A dual circulating lubricating-oil system is installed for each engine. This comprises a single-pressure pump for oil delivery from the supply tank to the engine lubricating system, a separate pressure pump for oil delivery from the supply tank to the piston cooling system and a scavenger pump for oil delivery from the engine pump through a four-element filter and three Harrison oil coolers into the supply tank. The capacity for the system is 190 gallons. A motor-driven dual pump per engine drives the return-flow fuel system. The fuel tank capacity is 1,200 gallons per section, or 4,800 gallons for the locomotive.

The electro-pneumatic trunk-line control system comprises: (*a*) An engineman's control station containing throttle with engine-speed control mechanism, motor connection lever, reversing lever with actuating means for control of traction motor reversing position, which lever when removed from the station, voids all locomotive movements; (*b*) four-valve, eight-position, electro-pneumatic engine-governor operating mechanism, mounted on the engine; (*c*) power-plant control

(*Continued on page 93*)

RAILROADS IN MINIATURE

MODEL ROADS FAITHFULLY PORTRAY MODERN RAILROAD OPERATION AND CONSTRUCTION

By ARTHUR Q. SMITH
VICE-PRESIDENT, WESTCHESTER MODEL CLUB, INC.

"NUMBER 19, The Owl, ready on 3, 10:02," comes the terse announcement from Central City Yardmaster's office to the Terminal West (TW) Towerman. In other words, the deluxe overnight limited is ready and waiting for passengers on Track 3, twenty-three minutes before leaving time. As in actual practice, railroad sleepers are ready for occupancy at a convenient hour regardless of the leaving time. This is one of the twenty scheduled trains on the regular time table of The Eastern Lines each operating night.

The Westchester Model Club, Inc., located in the abandoned Pelham Manor station of the New Haven Railroad, has one of the most complete scale model railroads. It is the result of the association and coöperation of a small group who, some ten years ago, were tied together by the "model bug," and their individual basement and attic systems. This group decided that there was enough interest in Westchester County to support a larger and more formal organization. From its inception as a corporate entity, interest has grown to the point where it is known around the world.

The principal object in forming a Model Railroad Club, other than to expand the hobby, is in the association of its members, and furnishing an outlet for the varied talents of those interested in the hobby. The results gained in a club are impossible on an individual's road. No single "model rail" can be an expert on every phase of model railroad building and operation. One may be especially proficient in constructing rolling stock, another motive power, another track work and so on through scenery, signalling, control circuits, etc. This is evident when visiting private systems and noticing the particular phase that individual excels in. It is obvious that a club can achieve near perfection through the combined efforts of its varied membership. Contrary to general opinion, the membership of the Westchester Model Club has a minimum of professional and engineering or railroad talent, but enough to solve any intricate problem that may arise.

The most fascinating thing about this model railroad hobby, is that it is the only scale model hobby in which the model can simulate the prototype in both detail and action. This will be realized as we describe the component parts of a model railroad system, and in particular The Eastern Lines.

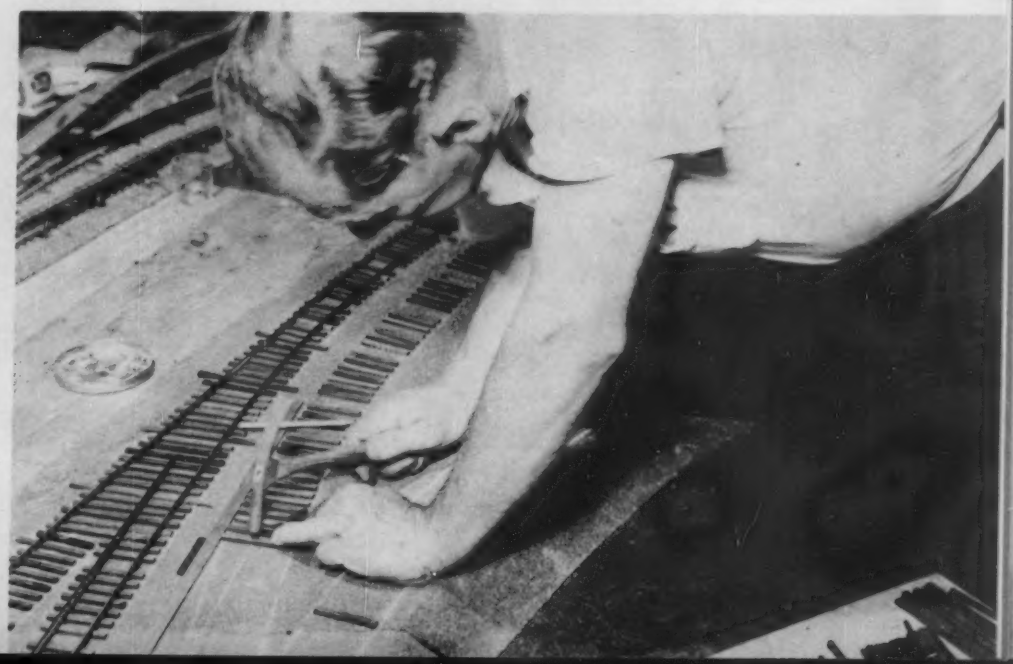
The first step was the selection of the scale or gauge. One-quarter inch to the foot, or "0" gauge was decided upon. When we secured the present quarters from the New Haven Railroad, a plan of the available station area was given to each member to have him sketch out his idea of a railroad system. The final adopted plan was a composite of about fifteen submitted. Flow of traffic, coach and terminal facilities, freight and engine yard as well as locomotive shops, car shops were given due consideration. For practical operating purposes, the necessary passing sidings as well as sidings at the communities served by the road were included in the design.

Complete and detailed track drawings were made, and the final projected design called for 2,200 feet of trackage. So thorough was this original layout, that only two or three minor relocations of switches and additions were necessary after actual operation began.

To go back to the club organization, it may be well to state here parenthetically that the membership was divided into several groups according to their abilities, each group under the direction of a superintendent. They were classified as nearly as possible according to actual railroad organization as follows: A Superintendent of Way; Structures; Buildings; Track; Power; Signals; Communications and Scenery. Later, a Master Mechanic was appointed whose duties are to see that all motive power and rolling stock is maintained in good order, and that it conforms to the standards of the National Model Railroad Association. With the various departments of construction provided for, each group could take up their particular job in order, and as a result of this thoughtful planning and coöperation, the railroad progressed according to schedule.

From the original master design, detailed drawings were made for the tables, lumber was provided, and the "gang" went ahead with their erection. Two-by-

Laying the ties to which the rails are spiked — *Westchester Model Club*



fours were used for all the framing, and one-by-sixes for all bracing and aprons, over which three-quarter inch decking was secured. This construction has made a very heavy and rigid foundation, making it unnecessary to anchor it to walls or floor. Over this base, three-eighths inch plywood was laid, cut to conform to the track roadbed, and covered with slate roofing paper to simulate rock ballast. As the erection of the tables progressed, the Track Gang followed with ties, rail, third rail or overhead catenary where specified.

While this general plan of construction is told in a few words, the actual job was slow and painstaking. It was eighteen months before there was enough rail laid to do a minimum of operating. As the system does not run on a plane, but climbs about here and there, particular attention had to be paid to the gradients. Continual surveying was necessary to check the construction crews. One particularly difficult piece of work was the construction of the four-track horseshoe curve with a turn-out in the middle of it. Not only is this a very graceful curve of varying radii, but the grade gradually increases from zero to two per cent, and super elevated according to the estimated speed and direction of traffic. In the construction of the Mountain Division, plans were drawn so that at no point is the grade over 2.2 per cent, which is about the maximum allowable for a single train without a helper engine.

Although scenery was provided for in the design, the actual construction was left until all track work had been completed. That is no actual scenery was built except the rough framing that had to go in when the tables were built. Where bridges were planned, the construction crew built up to the bridge abutments and filled in with a temporary span. At present a two track (144 scale feet) rolling lift bridge has been installed, and a single track (128 scale feet) Warren truss has been installed on the Mountain Division. Under construction now are nine bays of single track plate girder viaduct, two 60-foot spans of the same type, and a 160 scale foot double deck type, Bascule, carrying three tracks. This latter bridge is being modeled from plans furnished by the New York Triborough Bridge Authority of their new Eastchester Creek bridge now under construction. The Mountain Division calls for two more spans, one a timber trestle, and the other a long steel arch deck type. All steel work mentioned here is fabricated from twenty-eight and thirty gauge galvanized iron into structural steel shapes according to standard practice depending on the span desired.

Though unseen, the electrical work on the system has reached major proportions, and the job continues to increase to the point where this activity promises to dwarf all other work. With only about three-quarters of the permanent cables in place, 50,000 feet of wire have been used. As fast as the different parts of the railroad have proved satisfactory, it is connected in to the cable system which has been placed according to the original design. The original specifications of the power group involved considerable thought and engineering knowledge. The fundamental on which we based our power system, is the use of a common return heavy enough to carry 150 per cent of the estimated load. To this end, a loop of 00 copper trolley wire was installed under the entire roadbed. Connected to this loop are the negative sides of all lights, signals, switch motors, as well as every length (four feet) of running rail.

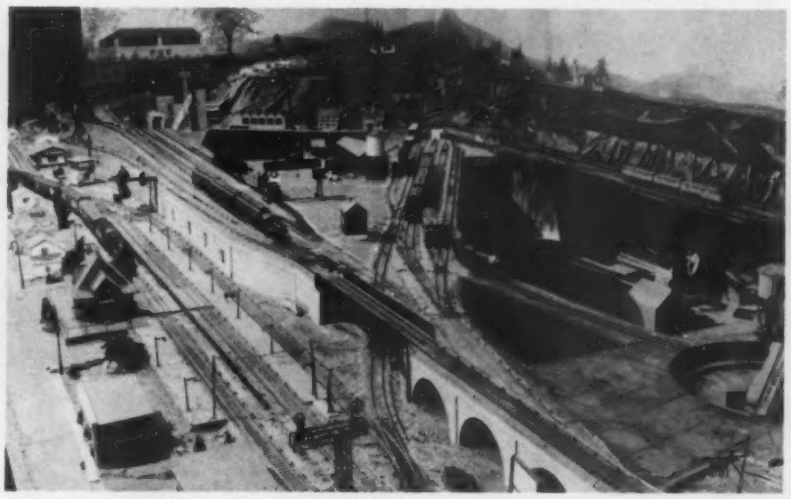
The "Power House" contains transformer banks of various sizes and capacities, batteries, and their associated charging equipment, rectifiers and protective apparatus. On the AC service to the railroad there is available 5 KVA at 115 V.; and 2 KVA at voltages varying from 2 V. to 24 V. For DC service there is at present a 16 V.-240 ampere hour Edison battery bank available, and 24V.-200 ampere hour lead battery bank. In the near future the traction power will be changed over from AC to DC which will be 16–32 V. three wire Edison system, so that motive power on the railroad can be reversed at the controllers. All feeder circuits from the switchboard are protected by fuses or circuit breakers. The one and most important feature of the power supply system is the use of adequate sized wire. It was realized that the successful operation of a model railroad requires the maintenance of maximum voltage at remote points. To this end No. 8–No. 10 and No. 12 feeders are used depending on load and length of run. No. 14 and No. 16 are only used for jumpers at local operating panels. The main negative switchboard bus is tied to the common 00 loop with a piece of 500 CM.

The traction circuits of the railroad are sectionalized, and all brought to a central set of "engineers' cabs" from which an engineer, by means of a multiple-point selector switch, can take his train from the starting point of a run, to its final destination. This eliminates the usual procedure of passing trains along from one division to the other, thereby insuring smoother operation and centering responsibility in a single road engi-

(*Continued on page 97*)

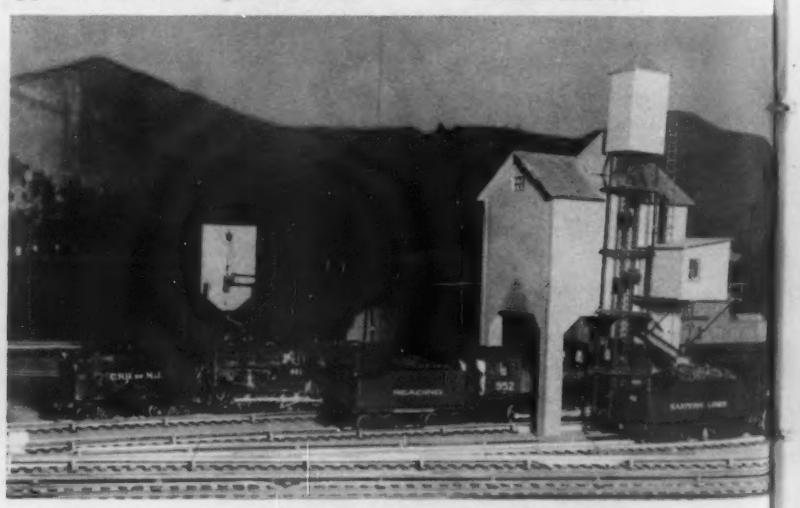
A bird's-eye view of an engine yard

Massachusetts Model Railway Society



Three road hogs being serviced with sand and coal at the approach to the engine terminal

Westchester Model Club



WHAT IS THE MATTER WITH THE RAILROADS?

THE NATION'S BELITTLED ORPHAN FINDS LITTLE SYMPATHY AND LESS SUPPORT IN THE STORM OF KEEN COMPETITION

By PROF. CHARLES B. BREED
HEAD OF THE CIVIL ENGINEERING DEPARTMENT

A RAILROAD official recently told me that his president wanted every project report to reach his desk as one typewritten page. The editor of *Tech Engineering News* asks me to state in two thousand words what is the matter with the railroads. This urge for brevity appears to be "in the air."

There is no business, including the railroads, which has sold its product to the critical public for one hundred years which has not either "folded up" or is now grappling with a lot of the problems of adaptation which this seething world has rapidly and relentlessly produced. Applied science has contributed many of these problems; social science has supplied its quota.

Railroad management is one of the most complicated and involved businesses in the world. It is complicated because it contracts to carry material goods of every kind from diamonds to doughnuts, every kind of mail and express; and every kind of person, white or black, well or sick, alive or dead. It does so in all kinds of weather and with a remarkable record for safety, although we must admit that during this past year there have been a few cases of human laxity and consequent loss of life.

Its competitors, on the other hand, contract to do a limited type of business and are not required by their charters to cover the entire transportation field in any comprehensive manner. Therefore, they enter the profitable fields of the transportation business and avoid the unprofitable. They can skim off the cream and leave the milk to the railroads. And this is precisely what the trucking industry is doing.

The amount of tons or ton-miles of revenue freight carried on the railroads in the present year compared with that carried in 1920 does not show a complete picture of what has happened. The railroads are still carrying the bulky materials over long hauls at low prices; these heavy materials go at the lowest rates. The trucks have taken the merchandise which carries a high tariff and which does not run into high tonnage.

In the past twenty years this country has spent a greater amount of money in creating new transportation agencies than it spent in the previous century. This has produced transportation facilities, including railways, highways, waterways, airways, and pipe lines, which are greater than business needs demand. In 1920 there were 253,000 miles of railroads and only a very few miles of highways of a class suitable for heavy trucks. Today there are at least as many miles of high type through, motor-truck highways as there are railroad miles; there are 500 times as many passenger automobiles as there are passenger railroad cars and two to three times as many commercial trucks as freight cars. Transportation facilities have been more than doubled.

There has been no such corresponding increase in traffic in the past twenty years; the existing traffic, therefore, is now being divided among these various agencies. It should be so divided that each agency holds its rightful economic field without Government aid.

Since 1920 more than $18,000,000,000 has been spent on improved highway facilities. Most of this money has gone into the construction of roads for highway transport which directly competes with the railroads. For the most part these main highways parallel the railroads and sometimes run for miles right alongside of them.

In recent years a billion dollars of Government money has been spent for improving inland waterway transportation. These waterways also compete with the railroads and run parallel with them.

Because aviation is heavily subsidized its traffic is many times what it would be if financed wholly as a private transportation enterprise.

The gas, gasoline and oil pipe lines are extending throughout the country. They, however, are on a business basis. They pay their own way, are self-supporting, and are not subsidized.

Every one of these five agencies, including the railroads, is being developed through engineering skill. Their economic fields are likely to change as applied science produces more economical transportation facilities.

To promptly meet these changing conditions requires a flexibility which the railroad, with fixed rights-of-way and terminals, does not possess in the degree its highway competitor does. When a railroad buys a new locomotive or car, the railroad corporation has to bear the cost; the tariff is not increased. But when a new automobile model comes out, the consumer, the purchaser, pays the bill. Generally speaking, the rolling stock of a railroad has a life of from fifteen to twenty-five years. Highway competition has developed during a similar number of years. Without available funds and with a plant which is by no means obsolete, it is difficult for a railroad administration, whose plant it not making a reasonable return on its capital, to convince its board of directors that they should throw away suitable rolling stock and purchase streamlined trains or that they should purchase a controlling interest in their competitor.

(*Continued on page 96*)

SPOTTING DANGER

INVISIBLE RAIL DEFECTS LOCATED BY SPERRY DETECTOR CARS

By JOHN A. SIBLEY, '43

ALTHOUGH capable of causing disastrous railroad accidents, many rail defects cannotbe detected by visual inspection or other simple methods of testing. To locate such hidden defects before they cause a serious derailment is the purpose of the fleet of Sperry Detector Cars.

Each car is a self-propelled unit which moves along the track being tested at a speed of from six to eight miles per hour. A pair of heavy metal brushes is suspended on each side of the car and pass a large current of low voltage through each rail. This current forms a magnetic field that is distorted by any defect which changes the structure of the rail. A coil is suspended slightly above the rail between the brushes so that a current will be induced in the coil by the current through the rail. This current is greatly amplified and made to operate a recording pen on a moving record-tape and a paint gun under the car. Thus the car produces a permanent record of defects in the track in addition to marking the exact spot where the defect was found.

Sperry Rail Service

Cross section of rail head with transverse fissure

The principal rail defects and the ones for which the cars were originally designed are known as transverse fissures. Often called "rail cancers" because of their slow, progressive growth, these fissures represent a sub-molecular separation of the metal inside the rail head. Starting from a small nucleus, the defects develop under the impact of heavy loads and high speed operation, until they result in the complete failure of the rail. The growth is usually quite slow, but there have been cases where a defect, so small that it could not be definitely identified, has grown overnight with the passage of several heavy freight trains to a fissure of dangerous dimensions.

The detector car is the invention of the late Dr. Elmer Sperry, the electrical genius who numbered the gyro compass and the high intensity arc light among his many important inventions. He became interested in transverse fissures in 1923 when rail failures from this cause were greatly disturbing railroad managements. Many scientists had attacked the problem and failed, but Sperry, after five years of intensive research, was able to produce the first crude, but effective, detector car.

The first units consisted of a motor car and detector car having a total weight of only 25,000 pounds. A current of 2,000 amperes was employed. In 1934 the second fleet of cars was constructed, each weighing 65,000 pounds and employing the improvement of "pre-energization." It had been found that the detecting apparatus functioned much more effectively the second time the car went over a rail, and this fact was properly attributed to the establishment of a definite magnetic polarity by the earlier current. The "pre-energizing" unit consists of a third set of brushes which pass a heavy jolt of electricity through the rail in advance of the detecting current. This results in an increase in efficiency of 25 to 50 per cent.

The present fleet of 14 single car units was constructed in 1940. Each car weighs 140,000 pounds and employs a detection current of 4,500 amperes in addition to the "pre-energizing" current of 2,500 amperes. On the original cars the sled, or searching unit which carries the induction coil, was mounted directly on the brush carriage frame, but in the new cars the sled is in an independent mounting riding the rails on small

wheels. This results in a constant distance between coil and rail, and hence more accurate results. Multiple-coil searching units containing four coils in staggered position have replaced the original two-coil units. Thus a larger area of the rail head is covered, and fissures are detected which were formerly missed.

Perhaps the most important improvement incorporated in the new cars is the ability to detect fissures under engine driver burns. As these burns would produce reading similar to those of fissures, defects in the vicinity of the burns would often be attributed to the burn alone and hence remain neglected. The result was sometimes disastrous. For example, on one Christmas evening fifteen heavily loaded freight cars were derailed with a damage of $100,000 in addition to paralyzing an important double track. A detector car had just passed over the track and an examination of the recorder-tape showed that defects had been detected but that they had been attributed to driver burns.

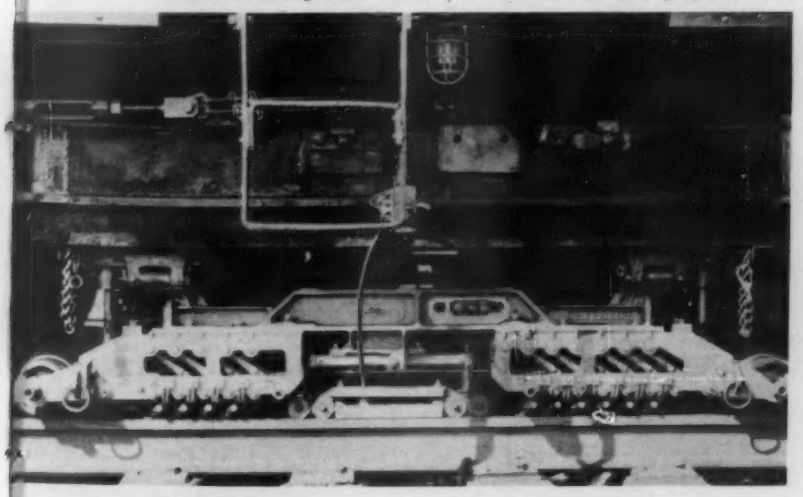
To prevent such mistakes a new detecting system was developed. In addition to the single recording pen for each rail, the new system employs two additional pens with improved amplifying devices. One of the three pens is insensitive to burns, ordinary flowed metal, and shelly spots, while either one or both of the other pens indicate fissures. Thus the reading of each pen has a distinct meaning, and, by a simultaneous examination of the three recordings, fissures may be distinguished from burns. This system has also proven valuable in detecting a form of progressive fracture often associated with driver burns, shelly spots, or even with the small head checks which appear at the corner of the rail head. Although once considered superficial, such defects have proven to be as dangerous as transverse fissures.

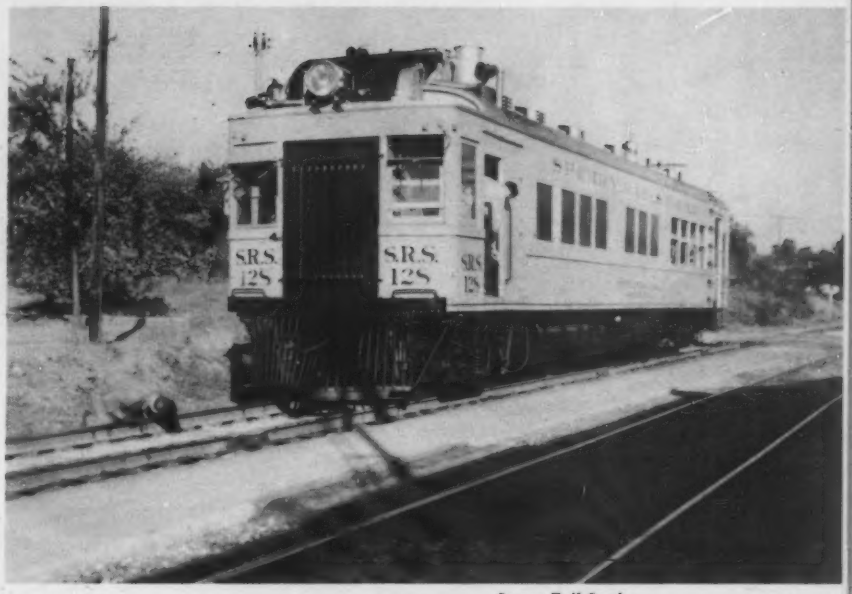
It was found that heavier rail sections required a higher energizing current than light sections, and, therefore, larger generators were installed to meet the demands of the heaviest rail. A low current pen was added which enables an operator to know when a length of rail, because of the presence of rust, grease, or even dead weeds, had failed to receive a sufficient energizing current for satisfactory testing. A set of calibrating instruments has been placed in each car, and is switched into the circuit several times during the day.

The number of defects located had increased greatly since the first crude car was developed. In 1928 a total of 444 miles of track were tested and eight fissures were found per 100 track miles. In 1934 the improved cars

Close-up of detector unit consisting of brushes and searching coil

Sperry Rail Service





Sperry Rail Service

One of the fleet of fourteen self-propelled detector cars

tested 41,000 miles and found 20 fissures per 100 track miles. The demand for the service continued to increase, and in 1940, 103,000 miles were tested and 23 fissures were detected per 100 miles. Such an increase in relative frequency of defects can of course be attributed in part to the improvements in design of the cars and the greater experience in their operation, yet one cannot consider these figures wholly indicative of the greater efficiency of the new cars. Factors such as age of rails, differences in rail steel, and increased volume of traffic undoubtedly effect the proportion of defective rails.

The detector cars were originally designed to locate transverse fissures, but it was soon discovered that other types of defects could be located. It is no longer necessary to rely upon the visual inspection of trackmen to locate vertically and horizontally split heads, because the most modern detectors are able to detect large numbers of them. Actually only about 40 per cent of the defects found are transverse fissures. Of the 52,000 defective rails located during 1940, 21,000 were due to transverse fissures, 3,000 to compound fissures, 3,000 to engine burn fractures, 10,000 to horizontal split heads, and 15,000 to vertical split heads.

Many roads have established the practice of having their principal tracks checked once each year and it has usually been the result that for two or three months afterwards no fissures would be found in service by the trackmen. The appearance of defects after a few months, however, might necessitate inspections at intervals of less than a year. Because of the great number of variables, such as quality of rails, traffic conditions, and degree of maintenance, each road must determine for itself how often the rails should be tested and at what times during the year the tests should be made. This can best be done by examining well-kept statistics on the frequency of failures for different periods of the year.

It is difficult to measure the actual value of detector-car testing, but it is significant that during the thirteen years of operation over 1,100 miles of defective rails have been located and removed, rails which might have caused expensive accidents. Yet aside from any economic consideration, there is little doubt that the Sperry Rail Service is one of the greatest contributions that has ever been made to railroad safety.

A FUNDAMENTAL DEVELOPMENT IN SUSPENSION FOR RAILROAD CARS

(Condensed from "MECHANICAL ENGINEERING," November, 1940)

HIGH speed in railroad-passenger-train operation is no novelty, nor is the achievement of passenger comfort with leisurely schedules. However, high speed with comfort presents problems which have thus far necessitated extensive improvement in rail and roadbed, involving expensive track realignment and surfacing. Such changes, merely to accommodate high-speed passenger equipment with some degree of comfort, surely are not economical, and therefore provoke the thought that a study of the riding problem, based on fundamental dynamics, might yield a truck-and-body suspension system which would provide comfort at high speed on ordinary track.

The wheels of a railroad passenger truck, in rolling along a track, are constrained to follow all the vertical and lateral irregularities existent in the tracks. These irregularities may be minimized by careful and expensive maintenance of way, but never completely eliminated. Additional lateral wheel motion occurs as oscillation within the limits of flange clearance, induced by wheel-tracking errors and truck nosing. Inadequate curve compensation and improper rail alignment on curves also give rise to lateral forces which seriously affect the stability of the car body mounted on trucks in the conventional manner.

The support of the car body on the wheels must provide not only adequate isolation against these vertical and lateral wheel motions, but also stability under all ordinary operating conditions. As is well known, the car body may be isolated against vertical vibrations by using springs having a large static deflection. A ten-inch deflection is common and gives a resonant frequency of one cycle per second. The transmissibility of such a system, the ratio of the body motion to the wheel motion, is low for all track irregularities which occur at high speed, and a high degree of comfort results.[1]

Conventional Types of Spring Suspension

However, in conventional railroad-truck construction, the springs are at a considerable distance below the center of gravity of the body, and instability in the form of objectionable and even dangerous body roll results from the use of "soft" springs.

Precisely this experience in the automotive industry followed the use of springs of greater and greater static deflection. Body roll, particularly on curves, became objectionable, and has been minimized by cross-stabilizers or "sway bars" designed to give the body freedom of vertical motion but restricted roll. This scheme has been incorporated in some recent railroad trucks in an effort to control the instability of soft truck springs. However, some of the benefit of soft springs is lost because on standard track with staggered rail joints, free truck roll is desirable and the stabilizers act to stiffen the springs for this type of action.

Lateral freedom of the suspension system is also desirable in order that the wheels may be free to follow the track irregularities without transmitting these motions to the car body. The swing hangers of the standard truck provide this freedom but, due to limitations of space, are rather inflexible in design.

[1] "Vibration of Rail and Road Vehicles," by B. S. Cain, Pitman Publishing Corp., New York, N. Y., 1940.

Advantages of Above-Gravity Suspension

In view of the limitations of the conventional railroad truck, the object of the development forming the basis for this paper has been to produce a car-body suspension system which would provide the requisite isolation against vibration and maintain stability. The goal has been comfort at high speed on ordinary track with safety and economy of weight. The fundamental scheme has been to support the car above its center of gravity in a manner which is inherently stable. Ideally, the above-gravity suspension hangs the car above its center of gravity on an imaginary longitudinal axis which is allowed all necessary vertical and lateral movement against soft-spring restraints. The wheels follow the rail irregularities while the body floats about a central position.

The above-gravity suspension has a further outstanding advantage over the conventional truck. In taking curves above superelevation speeds, the outward force acting on the center of gravity causes the body of a conventional car to roll outward on the truck springs, adding to the discomfort of passengers. However, with the car supported above its center of gravity, the outward curve force rolls the body in the direction for comfort, pendulum-wise, adding effectively to the superelevation of the track in so far as comfort and stability within the car are concerned.

A practical realization of the benefits of the above-gravity suspension has been the purpose of the design and experimental work leading to the cars described in this paper. The original designs and the subsequent modifications adhere to a basic ideal car mounting in which the car is elastically supported at each end on a virtual, universal center bearing on the longitudinal center line above the center of gravity of the car body. This virtual support permits sufficient universal swivel action of the truck relative to the car body to account for all operating conditions, and the springs together with the positioning linkage coöperate to achieve the desired vibration isolation. The actual car support, however, is at two points on either side of the car center line with a third attachment between the truck and the car body below the floor level. Consequently, no objectionable interference with normal use of the car interior is introduced by the suspension. The desired motions are provided by flexure of the support system, suitably positioned and restrained. In the early models, mechanical linkage and pivoted support arms provided the universal swivel action. In the present form, all motions between the truck and car body occur solely through elastic flexure, leading to an extremely simple lightweight truck and suspension system.

The practicability of the above-gravity suspension system has been convincingly demonstrated in trial runs of a two-car experimental unit.[1]

Basic Principles of Suspension System

The rear truck of this unit illustrates the basic principles involved in the suspension system. The car body rests on soft coil springs which are recessed into the car structure on either side of the center aisle. These springs carry only vertical load and allow, within limits of safe stress, sufficient horizontal movement of the top relative to the bottom for all lateral and turning movements of the truck in normal service. A basic analysis of the mechanics of helical springs disclosed two facts which made the application feasible with properly designed springs; *i.e.*, the stresses, due to these lateral deflections, are not severe, and the springs can be deflected laterally and yet be stable. Lateral movement of the car body floating on the main springs is restrained by control arms and links which act on the body above the center of gravity. The control arms mounted in rubber give a variable spring rate for lateral motion, so that the car floats about a center position with small restraint, equivalent to the action of very long swing hangers, and is brought to a yielding stop for large lateral swings. The longitudinal position of the truck is maintained by the thrust tube or "wagon tongue" which is anchored in rubber at one end to the truck frame and at the other to the car underframe. The rubber mountings of the longitudinal tie permit lateral movement of the truck and angularity on curves as well as constituting barriers against noise transmission. The coil-spring suspension involves no sliding or rotating parts carrying the weight of the car. The elements which have been described replace the center plate, side bearings, bolster, chafing plates, bolster springs, spring plank, and swing hangers used in all standard passenger-car trucks.

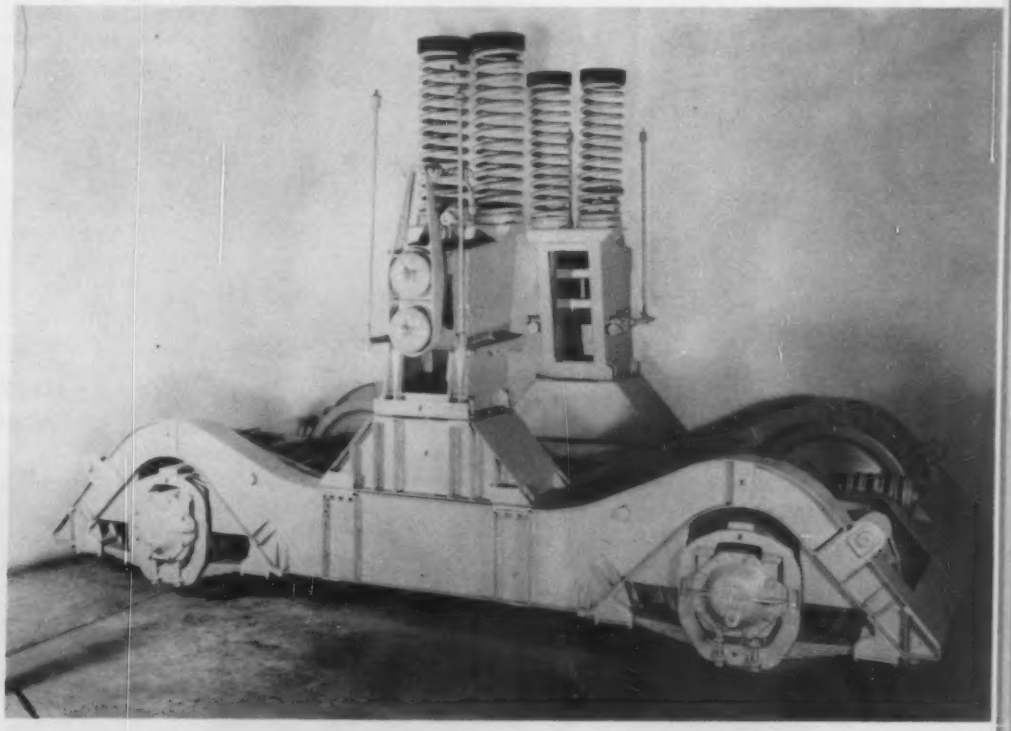
The car bodies of the test unit were, for reasons of simplicity, fabricated of plywood into stressed-skin or semimonocoque structures. High strength and rigidity were thus obtained at minimum weight. Moreover, most of the usual auxiliary equipment of passenger cars was omitted from these units so that the two-car articulated unit one hundred forty-five feet in length weighed only thirty-three tons on the rail.

Road-Test Program

An extensive road-test program, during which various changes were made, showed that the only modifica-

(*Continued on page 94*)

Truck for experimental car



[1] "New Pendulum-Type Cars Tested," *Railway Age*, Vol. 104, No. 7, 1938, pp. 294–295.

"IN UNITY THERE IS STRENGTH"

THE MECHANICAL BUTT WELDING OF RAILS BY THE OXY-ACETYLENE PRESSURE METHOD OVERCOMES RAIL JOINT DIFFICULTIES

By G. W. HARRIS

CHIEF ENGINEER OF THE ATCHISON, TOPEKA AND SANTA FE RAILWAY SYSTEM

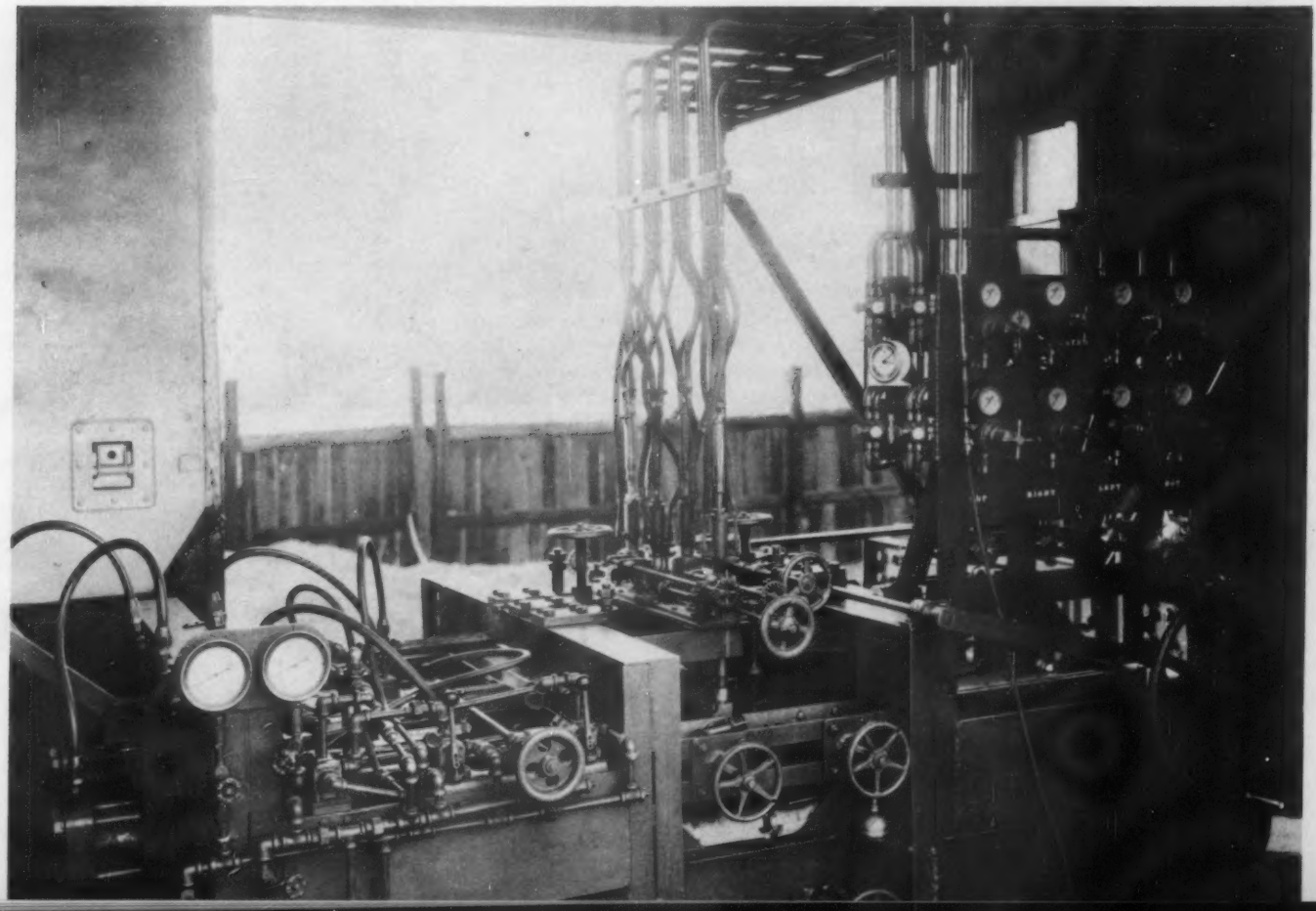
RAIL joints whose locations fall within the limits of highway grade crossings require continuous attention from railroad maintenance forces and in addition are often a direct cause of early breakdown of paving material. For these two reasons, railway engineers have found that the most satisfactory method of joining rails for grade crossing service is to make a complete weld of the two or more rails required.

Although rails have been welded by the oxy-acetylene hand butt-welding procedure for many years, it is only recently that a process has been invented which gives us a suitable mechanical system of joining steel rails by welding without fusion. In this process, developed after considerable study and experiment by the Oxweld Railroad Service Company, the rails are joined by the use of high pressure and heat. The joint is not strictly speaking a fusion weld but it is an oxy-acetylene pressure method of welding in what is described as the solid state, where the metal has not reached the fusion or molten state.

Prior to the development of the oxy-acetylene process for pressure butt-welding of rails, the Atchison, Topeka and Santa Fe Railway System used an oxy-acetylene method employing the hand welding blowpipe. The welds made with this process were reasonably satisfactory. However, the pressure butt weld has been found superior and is now being used generally for the welding of road crossing rails. While the practice on the Santa Fe to date has been confined to the welding of crossing rails, this process has been extended on other railroads to rail through station platforms, over bridges and through tunnels.

Due to the irregular contour of railroad rail, the oxy-acetylene process with its convenient source of heat offers an ideal medium for heating the parts to be welded by the pressure method. Laboratory tests made in the course of development showed that welds made by this process were of high quality and that this method effected the least change in the physical characteristics of the weld zone from those of the base

Figure 1. The oxy-acetylene pressure butt-welding machine is used for joining rails for road crossings. *Santa Fe*



metal in the rail. This is easily understandable since there is no other metal used in making these welds, rail metal alone being used in the joining.

The Pressure Welding Machine

The pressure welding machine (Figure 1) consists of a framework in which are mounted a series of manually controlled and hydraulically actuated clamps for holding the rails in position during the welding process.

Pressure is applied to the clamps by means of a small pump which builds up hydraulic pressure necessary for holding the rails together for the welding operation. Four blowpipes are provided with special heads formed to the contour of the rail section. Oxygen and acetylene for the blowpipe operation are supplied from manifolded cylinders usually located just outside the door of the special box car in which the welding equipment is carried. In addition to the welding machine proper, a normalizing unit is also provided for reheating the weld to refine the grain structure. A special oxy-acetylene blowpipe guiding mechanism is used also for trimming some of the upset metal from the rail after the weld is made and before normalizing.

Planning the Rail Welding Program

In planning our year's butt-welding program for the elimination of joints in grade crossings, a study is first made of the locations for which new rail has been authorized. This determines the number of extra long rails to be needed for these locations. The standard rail length is 39 feet. For ordinary crossings, rails of 78 feet (two rail lengths), or 117 feet (three rail lengths), are usually long enough. However, in wide city streets and where the rails cross the pavement at an extremely acute angle, rails considerably longer are often necessary.

From our determination of the number of rails and the lengths into which they are to be welded, our rail order to the mill is made up. The steel mills are instructed to furnish the rail without bolt holes on the ends to be welded, as it is desirable to have rail of full strength. In addition, where it can be conveniently done, we request the steel mill to mill-finish the ends of the rails, squaring them so that little or no grinding will be necessary for a close fit in the welding operation.

In connection with our mill order for rail steel it might be well at this point to state that an accurate record is kept of the locations in track of all of our rail by individual mill heat numbers. This is for the purpose of being able to identify and locate rails from any specific heat. If it should develop that an excess number of identified transverse fissures or other failures occur in any heat, the entire heat is ordered out of track and the location record which we keep enables us to find where the rail has been placed. For this reason also all rails to be welded in any one string are always selected from the same heat number. The advantage is apparent, for if only one of the welded rails belonged to an identified heat, it would not be a good practice to remove the good rail along with the bad one.

Working Procedure

The most satisfactory plan for welding rails in production is to set up the special welding machine at some convenient centralized point on the railroad and to do all the welding at this location, distributing the welded rail strings from this point to the locations where they are to be laid in track.

Rails for the welding operation are stored alongside the work track, and if grinding is necessary, it is done at this point. On mill finished rail any grinding necessary is seldom more than a polishing operation to keep the ends entirely clean and to avoid the inclusion of any dirt or oxide in the joint. If the rail is furnished without mill-finished or squared ends, grinding is done on the job; in this case, the rails are stacked in crib fashion so that the end of each rail extends out and can be easily ground and tested for squareness with a try-square. The ends of the rails that have been ground and are ready for welding are coated with a protective grease which is removed before welding, by the use of some good cleansing agent.

The rails to be fed into the welding machine are carried on a separate car ahead of the welding operation. They are positioned on special skids so that they can be easily moved into place in the machine.

When the two rails are placed in the welding machine, powerful hydraulically operated clamps, formed to the shape of the rail itself, grip the sides of the rails and force the ends together with the high pressure necessary for this method of welding. This pressure equals about 2,500 pounds per square inch. The pressure is applied before any heating is done and it is kept on the two rails until the welding is completed. The hydraulic pressure is provided by a small power unit which also operates a pump for circulating cooling water through the welding heads to prevent them from being overheated.

There are four oxy-acetylene welding heads in the machine: one positioned at the top, one at the bottom, and one on each side of the rail. The flames of the welding heads are lighted, the bottom head first and then after a few seconds the top head and then the two side heads. Each of these heads contains a number of

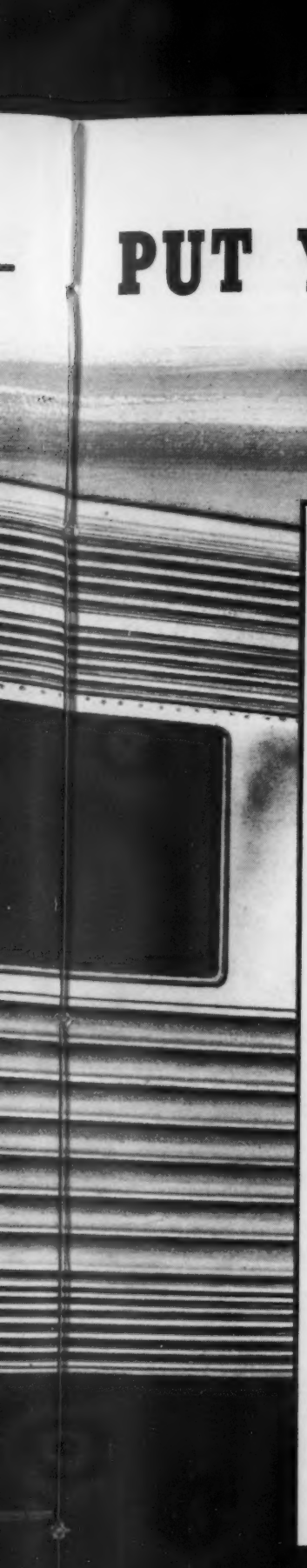
Figure 2. When completed, the weld has a ridge of upset metal which must be trimmed off in the finishing operation *Santa Fe*

welding tips which produce flames of different sizes so as to give an even heat all the way around the contour of the rail ends. As the metal reaches the plastic state, under pressure, it upsets, so that when the weld is completed there is a ridge ranging from one-quarter to one-half inch in height extending around the completed rail at the welding zone (Figure 2). As this metal upsets, each rail is shortened about three-eighths or three-quarters of an inch over the completed weld. This is an important factor because it is the measure by which the completion of the weld is gauged.

The operator watches this upset until the necessary length has been reached and then the flames are turned off, the pressure is released, and the rails are allowed to

(*Continued on page 100*)

If you want to sell the public—



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FRANKLY SPEAKING...

RAILROADS IN NATIONAL DEFENSE

Ever since the railroads became an integral part of the American economic system, the question has always arisen, "Is the railroad mechanism of the United States sufficiently reliable and well enough organized to handle the exigencies of a war period?" The roads have inevitably said yes; the government has conclusively said no.

So far, Congress has not been wrong when it has doubted the adequacy of private operation of transportation during times of stress. The railroad bottleneck of the first World War, caused by very poor management, held up construction work and shipment of men and supplies for a dangerously long time. Had the government not taken immediate charge of the situation, the Allied cause might have been seriously affected.

Thus the government has a good reason to be skeptical about private railroad operation. Almost twenty-five years have passed, however, since that unfortunate incident, and today most railroad magnates sincerely believe that their lines can be maintained and operated without any difficulty, regardless of the load required for defense work. New and more efficient apparatus, more extensive lines, and better trained men, they claim, make the railroads more capable of handling terrific overloads, even under private control, than ever before. All the railroad publications of the present day are enthusiastic about the self-sufficiency of modern transportation.

Nevertheless, these publications do admit that the railroads have certain chronic troubles that must be corrected before really smooth operation can be attained. Many of these complications are hangovers from "pre-Interstate-Commerce-Act days." Perhaps the most noticeable is that concerning rate discrepancies due to keen competition with trucking, waterway transport, and air traffic. The railroads are self-supporting, and operate with a large overhead; on the other hand, trucking and waterway overhead is small, and such corporations are ofttimes financed by private capital. Consequently, the railroads must demand higher rates to make a profit. In the past few years, automotive transportation has taken much railroad business, and the latter have had to lower their rates to a minimum.

As a consequence of lowered rates, another problem presents itself: the lack of sufficient equipment to meet emergency needs. True, time has brought better equipment, but lack of capital has resulted in too little of it. For this reason, in spite of present optimism on the part of railroad officials, government financial aid would be necessary before the roads were in condition for a heavy defense program.

Of great significance during wartime is the proper distribution of railroad equipment. During the last war, with all the main lines to the east of the Mississippi, there was a definite shortage of carrying equipment in the West where much defense material was prepared. Only after the government assumed control of the roads was a proper balance of engines and cars throughout the country established. Today, however, the railroads claim that a reasonable distribution has been made. This may be true, but the government prefers to be on the safe side, and doubts it.

The question of profits in wartime deserves some consideration. Defense materials, such as coal, iron, munitions, etc., are carried by the railroads at a loss. The largest profits are made on light and perishable freight, and passenger traffic. In peace, the roads carry coal simply as bulk, since they lose less money that way than if they left the cars empty. Now when the country is at war, the government has priority rights over shipping, and that shipping will be confined to non-profit cargoes like those previously mentioned. The railroads must, therefore, be prepared to operate at a considerable loss during the war, and it does not seem likely that they will be able to manage without federal help.

In an attempt to make up for this loss, the individual lines have often resorted to an old device. In point-to-point shipments, there is a definitely established rate, but that rate is divided among the lines carrying the shipment in proportion to the mileage covered by each. It soon became a policy in the last war for the large lines to get the largest portion of rates by shipping cargoes along the longest route between two points. This was, obviously, of great disadvantage to the government, and caused a large amount of unnecessary congestion. In the considerations of private management of the railroads during a war period, this is justifiably one of the government's greatest concerns.

The railroads have many good reasons to believe that they are adequately prepared for the worst; similarly, the government has many good reasons to believe that they are not. But when the time comes, as it probably will, for complete regimentation of business by the federal executive, comprehensive investigation will probably show that the railroads are no more self-sustaining than are any of the other organs in the preparation for national defense.

RESEARCH IS VITAL

Dr. Vannevar Bush, President of the Carnegie Institution of Washington, was appointed not long ago to lead the Research Division of the National Defense Advisory Commission. The function of this division is to coördinate research activities in laboratories of the government, industry, and colleges. The Bureau of Standards, the National Academy of Sciences, the National Research Council, and leading technical schools have a common goal. However, for the present what is being accomplished must remain largely unknown to the general public, because of the highly confidential nature of the work.

The continuance of pre-war production research is a big problem. Dr. Karl Compton, as chairman of the Advisory Committee on Scientific Research of the National Association of Manufacturers, found in a recent survey that out of one hundred and eighty-eight large companies, an average of two per cent of their gross income is spent on research. Of these companies, ten spend more than ten per cent on research! In a hysteria of urgency, factories are likely to operate overtime producing the paraphernalia of war according to present designs only. Actually, there should be as much technical advance in the manufacture of the next ten thousand planes as in the last, otherwise they will be obsolete when finished! Certainly to protect investments in war materials, at least as much if not more research should be carried on now as in normal times. It is the duty of our lawmakers to provide legislation that will require manufacturers of war supplies to speed up research as well as material output.

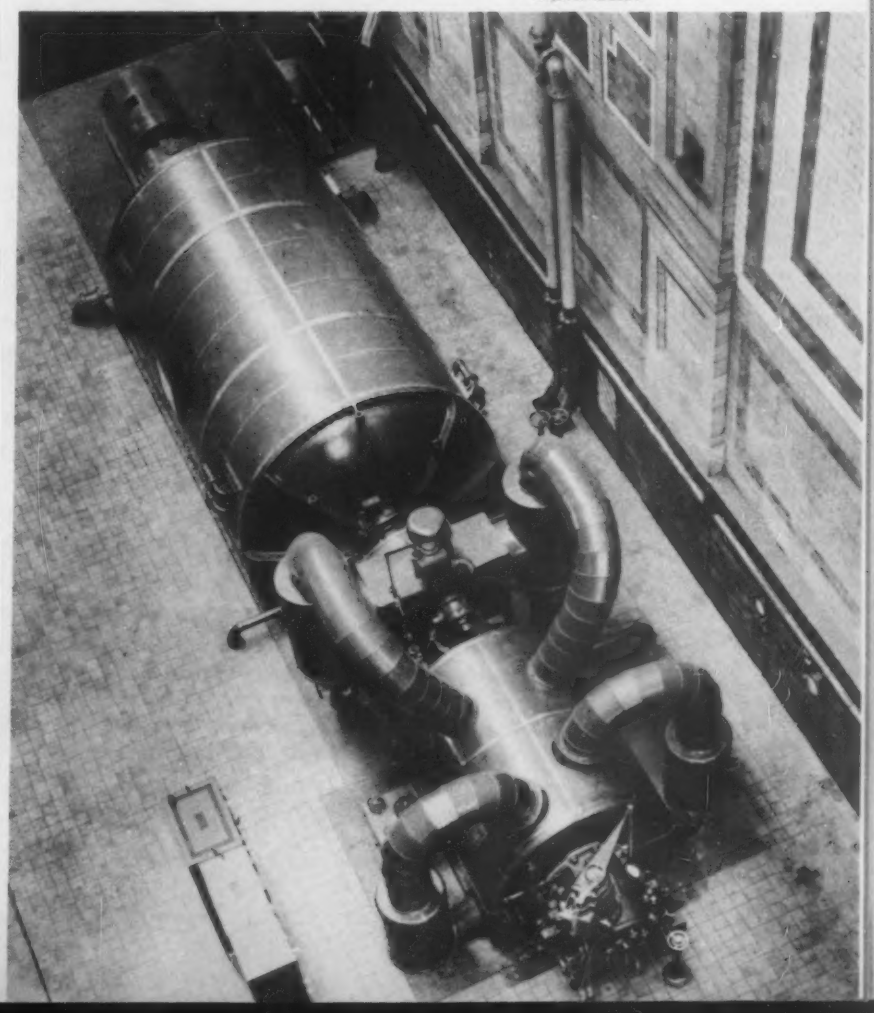
There are many problems to be solved: the use of sound in range finding or submarine detection; military use of optical instruments, the infra red ray, and radio communications are but a few. Research done in blood transfusions, aerodynamics, and physiology of high speed flying has been of incalculable value; but the subject of camouflage has been left to artists, who make use of or understand few scientific principles. In other cases, it is not so much scientific research or scientific application that is needed, as a general scientific approach.

The Haber nitrogen process (for converting free nitrogen of the air into explosive nitrates) made it possible for Germany to survive four years in the last war. Now, in this war, the Bergins oil from coal process provides Germany with a respectable fraction of her petrol needs. These two discoveries vividly illustrate how essential is the continuance of research during an emergency.

Regarding the speeding up of research and the coördination of national economy in general, the man of science has been conspicuously absent from important posts in the government at a time when scientific direction is most needed. The man of science has been relegated to an advisory role, while every research worker knows half the battle in science consists in asking new questions which the non-scientist cannot be expected to think of. This may be due to the refusal of many men of science to look beyond their specialization and to face their social responsibilities. However, it may also be due to the mistrust of science still to be found in many important quarters in business, farming, civil service, and among military authorities. The man of science should assume his place in national leadership.

One of the most important assets in a program of national defense is the large group of industries which, because of their support of scientific research, have been able to develop new materials and more efficient methods of transportation. Though research is expensive, in the long run, it returns the greatest of dividends and therefore cannot be neglected when most needed by industry and the nation!

General Electric

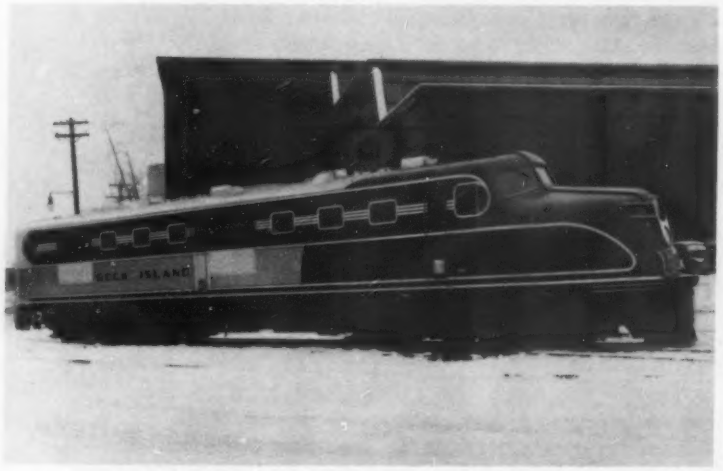


BRIEFING THE NEWS . . . . . .

THE NEW ALCO-G.E. 2000 HORSEPOWER LOCOMOTIVE

Designed for operation between Chicago and Tucumcari, Arizona, the new Alco-G.E. locomotives are each powered by two 1,000 horsepower turbo-charged Diesel engines, giving motive power for 120 miles per hour operation. The locomotives are equipped with six wheel trucks and each locomotive has a total weight of 330,000 pounds.

The general structure consists of a welded steel frame on cast steel trucks with a welded cab framing of truss design. The air-brakes and train control equipment are located under the low hood at the forward



end of the locomotive. In the 47-foot engine compartment, the two engines are placed in tandem and located on the centerline of the locomotive with the generators and the turbo-chargers at the forward end of each engine and the air compressors and the radiator ventilator fans at the rear of each engine. The two 1,600 pound/hour steam generators for train heating are located at the left side of the rear of the engine compartment, while a radiator chamber is located behind each engine. There are two radiator sections for each engine; one on each side of the locomotive. Each engine is a complete unit by itself and there is no connection between the two cooling systems. The cooling itself is accomplished by drawing air into the radiators in the side of locomotive and discharging it from the roof, while separate ventilators, located in the roof of the engine compartment, provide cool air for the engines, blowers, and boilers, and serve also to discharge heated air from the engine room.

Some of the more technical features of the locomotive include the provisions made for repair and maintenance of the engines. Hatchways are provided in the roof for the removal of the engines and also for the removal of the generators and train heating boilers. The main hatches have smaller openings with hinged covers as a means of access for the inspection and removal of pistons.

A unique feature of the motors is the built-in air-brake compressors mounted on the ends of each engine. A two-cycle two-stage compressor has been developed for direct attachment to the engine at the end opposite the generator, with the connecting rods of the compressor cylinders mounted on a crankshaft extension bolted to the end of the Diesel motor. The engine lubricating oil pump is mounted inside this air-compressor crankcase and is likewise driven from the crankshaft extension. This combination reduces the weight of the units, saves a considerable amount of space, and presents a much cleaner design.

— "*Railway Mechanical Engineer*," *March 1941.*

PLASTIC MODEL

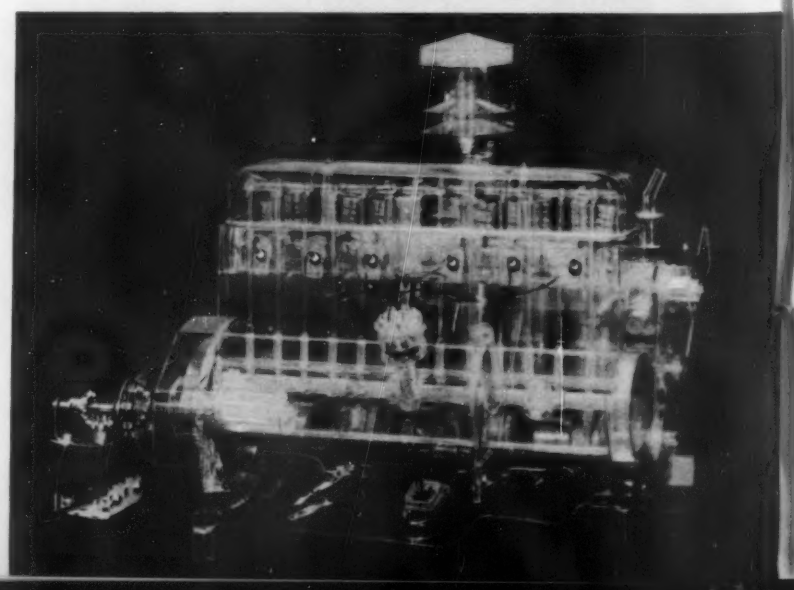
Plastic preproduction models are exact reproductions of the product-to-be. Faithful in detail and in coloring, they are frequently held to such exact dimensions that they serve as a guide to the mold maker. Such plastic models are insurance policies to the manufacturer. Despite the fact that the purchaser, the tool maker, and the mold maker can read blue prints, it is much easier to form opinions about a three dimensional model than it is to visualize what the finished product will look like from some circles, angles, and straight lines running helter-skelter on one plane. Moreover, the potential client can see how his article will look and function without the excessive cost of building the actual mold.

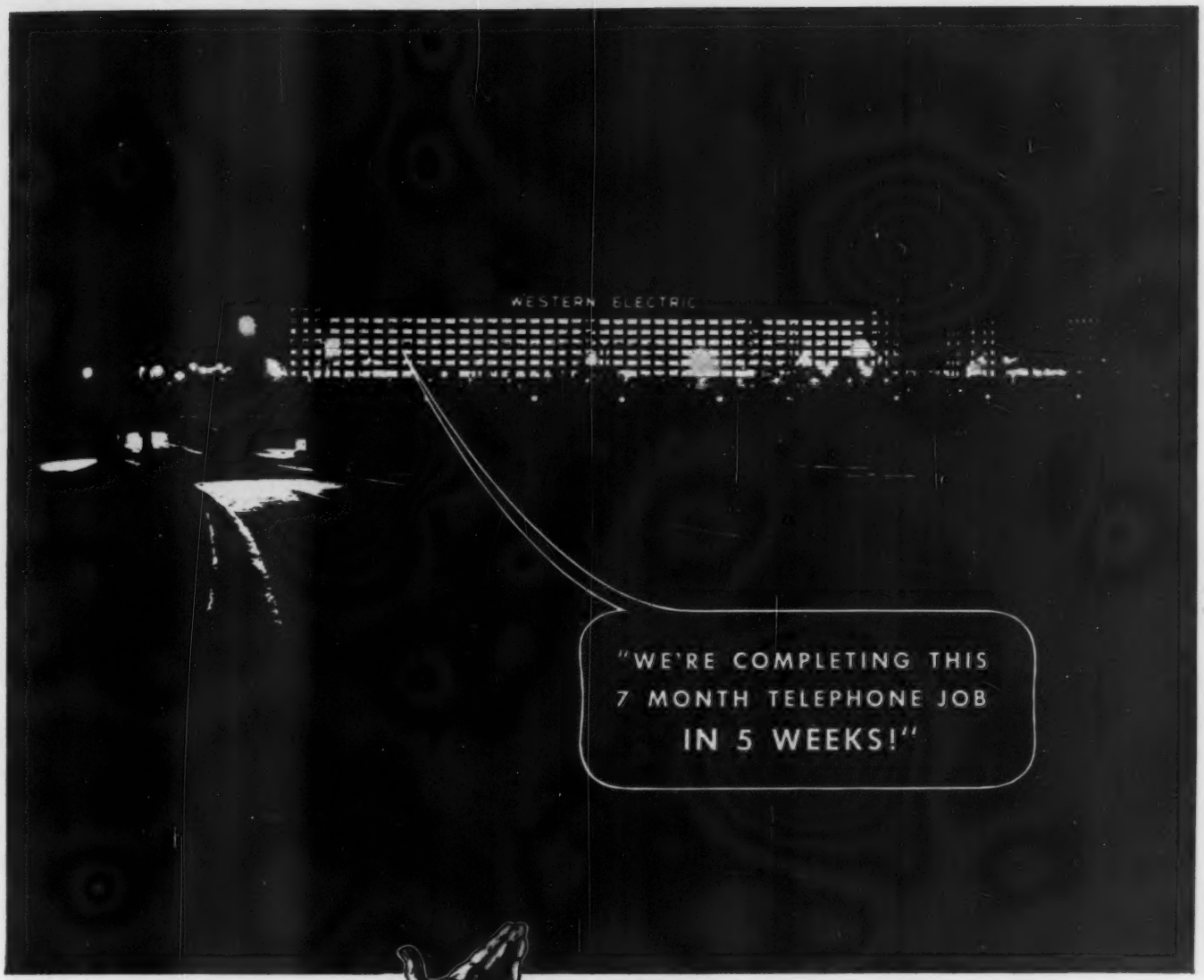
The cause and effect of a plastic model are far-reaching indeed. All work, including merchandizing, market research, even advertising campaigns, and of course the tool and mold makers, are dependent upon and stem from the plastic model. Previous to the model, everything has to be "visualized." With the model, the visual becomes a live three dimensional reality that can be handled by the manufacturer, the advertising man, and the salesman. Frequently revisions are found to be necessary, but the purchaser, the designer, the tool and model makers are paradoxically enough thankful for this disappointment — it is a much simpler job to revise a plastic model than a hard steel mold.

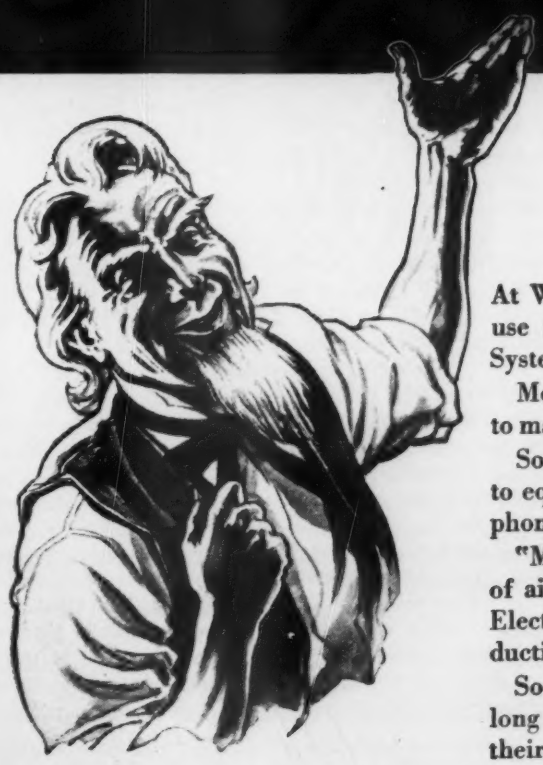
Most model makers try to employ the same type of plastic for the model as will ultimately be used in the finished product. The plastic model has the same appearance and contour of the ultimate article and thus can be subjected to all types of tests, if the finished product is intended to withstand such treatment in action.

The plastics generally used for models are: cellulose acetate, methyl methacrylate, cast phenolics and polystyrene, the choice being based on their availability in stock forms and blocks. The fact that there are transparent plastics is of great importance, particularly in industrial and experimental work. Actual working models housed in clear plastic give the engineers and manufacturers an X-ray view of the products' "innards." In that way industry can produce better and better articles with greater economy and assurance.

—"*Modern Plastics*," *April 1941.*







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"IT USED TO BE THE SPORT OF KINGS"

On or about June 1, Boston will witness the realization of an altruistic ambition. The inauguration of a sailing program in which both young and old alike will participate is the crystallization of a wealth of benevolent ideas and interests.

The organization to be credited on a truly commendable job is the Community Sailing Association, which has already erected a splendid boathouse on the Charles River Basin's eastern shore to bunk the as yet uncompleted fleet of forty dinghies.

The prime impetus given the program was that furnished by Mr. Joseph Lee of the Boston School Committee, who correctly deduced that sailing was a sport appealing especially to youngsters of the age at which most boys crave an outlet for excess energy. Psychologically, sailing instills a sense of lasting good sportsmanship, emotional balance, and accurate judgment. Mr. Lee's idea was realized in the construction of thirty-nine craft which provided enjoyment for nearly a thousand of Boston youngsters. The success of the idea was immediately evidenced, and the support for the new program of Mr. W. Duncan Russell, general director of Community Service, was enlisted.

Because of his wide experience in teaching sailing and heading sailing programs, the services of "Jack" Wood, Sailing Master of M. I. T.'s Nautical Association, were enlisted to head the new program. Contributing factors in furthering the idea were the Storrow Memorial Fund, the purpose of which is beautifying the Basin, and the Metropolitan District Commission.

Shore schools aimed at teaching these embryo yachtsmen the rudiments of "what makes a boat go" are already under way. Instruction for these shore schools is presently being conducted by members of Tech's Coxswain and Boatswain groups, along the lines of Tech's Nautical Association.

It is supposed that many schools — Boston College, Radcliffe, Harvard, Boston University, and Northeastern, to mention but a few — will actively participate in the program to further encourage intermural racing in one-design competition.

It is the goal of the Sailing Association that the program shall pay for itself, independent of assistance from the Community Fund, with which it is affiliated. The achievement of this aim is to be accomplished through membership dues, which in themselves range all the way from fifteen dollars a year to possibly twenty-five cents a month, dependent on the individual's ability to pay.

A glance at the boats themselves shows them to be machine-built, plywood craft, of overall length of thirteen feet three inches. A strong mahogany veneer will cover the plywood, providing for a glossy varnish finish. A feature of safety in construction makes the boats almost unsinkable. Being practically double-hulled, providing in effect a watertight bulkhead, the boat will sail pontoon-fashion. Another feature of construction worth noting is the hollow mast that has been designed sufficiently rugged to stand without supporting shrouds. This has been done primarily to alleviate the confusion of the novice. Two sails, a regular mainsail and a smaller storm sail, are provided for each boat.

H. W. Reynolds

NEW USE FOR GAMMA RAYS IN DEFENSE INSPECTION WORK

Radium salts producing gamma rays potent enough to penetrate ten inches of steel are being used to register the internal condition of a metal on film. Radium sulfate is used in the examination of steam turbines, propulsion gears, and auxiliary apparatus intended for use in United States Navy's ships.

In radium sulfate, the atoms split spontaneously, and this perpetual disintegration generates gamma rays which can pierce the hardest steels. Flaws appear on the film as dark areas. The rays are able to reach the film with greater intensity during an exposure period through flaws than through solid metallic structure.

Air bubbles and impurities in the metal parts of steam and propulsion equipment are ferreted out to prevent later development of any weakness. Turbine steel must withstand steam temperatures up to 1,000° F. and pressures as high as 1,500 pounds/square inch. The steel structure of a turbine steam chest resists expanding forces which are equivalent to the weight of a railroad locomotive.

When a piece of equipment is brought into the laboratory for inspection, a technician fishes a radium capsule from a sunken safe. The walls and bottom of the safe are four-inch slabs of lead; inside is a block of lead with small wells to hold the radium sulfate containers. A lead lid locks into place over the safe.

The capsules are suspended on a midget rigging placed within or beside the metal being tested. A belt of film can be placed around circular pieces of metal, such as pipe sections, and the film will register the gamma rays from a fixed radium sulfate source in the center. Exposure times vary from a few minutes to forty-eight hours and the time of exposure is determined with a special slide rule developed for this purpose by Navy engineers.

—"*Scientific American*," *May 1941.*

THE TECH ENGINEERING NEWS wishes to thank the student body for its support and co-operation during the past school year.

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TAPES — RULES — PRECISION TOOLS

DIESELS ON WHEELS

(Continued from page 76)

push-button box with fused switches for master control circuit, generator field, fuel pump and push button for engineman's helper call signal, and defroster blower switch; (*d*) locomotive light switch box with five push button controls; (*e*) instrument panel, indirectly lighted, containing air-brake gages, speedometer, and wheel-slip indicator; and (*f*) main-generator load meter to indicate proper motor connection.

The locomotive is capable of pulling long, heavy freight trains at a top speed of 75 miles per hour on level track. With fifty cars, it can negotiate a three per cent grade without a helper. Since such fairly steep grades are encountered in the West, special care has been given to the brake system. The brake-lever ratio is 5.66 to 1. Two 18-inch brake shoes per wheel give an average shoe pressure of 12,250 pounds in an emergency application. Based on an average loaded weight of 836,000 pounds for the locomotive, the braking ratio is 70 per cent with 50-pound brake cylinder pressure, or 95 per cent with 68-pound cylinder pressure. During operation of the new electric retarding brake, the power generated by reversed traction motors is fed back into air-cooled stainless-steel grids located in the roof where heat can be easily carried off.

The brakes are designed to exert a retarding force of 80,000 pounds at 22 miles per hour, with a lesser step at which the retarding force is 54,000 pounds at 33 miles per hour. At the higher step the grids dissipate 4,690 horsepower and at the lesser step, 4,753 horsepower. In either case the traction motors generate 540 amperes. The brakes are designed to retard safely down grade any load that the locomotive can haul up the same grade.

Among other mechanical improvements which have been instituted since the arrival of the first Diesel-electrics is the further development of a steam generator to meet heating and air-conditioning requirements. Improved crankshaft bearing metals are used. Wheels are improved, the service life of present wheels being approximately 250,000 miles with machining every 84,000 miles. Drop-forged aluminum pistons have been replaced by pearlitic malleable iron. By using effective oil filters, the lubricating oil drain periods in high speed Diesel locomotives have been increased from 5,000 to 100,000 miles. Cylinder liners now are removed for reconditioning when worn .020 inches, after approximately 325,000 to 500,000 miles. Crankshaft journals are reground with crankshaft in place in the engine by use of an especially designed machine. This is accomplished in six to eight hours, which avoids delay and out-of-service time for the Diesel locomotives.

In this era of railway transition, it is encouraging to note that from the technical viewpoint at least, the railroads have not lost their former vitality, and are constantly anticipating modern railway operating demands. The recent addition of the 5,400 horsepower Diesel-electric locomotive to Santa Fe's streamlined fleet is an outstanding example of the railroad's desire to give the public faster and better service.

A FUNDAMENTAL DEVELOPMENT IN SUSPENSION FOR RAILROAD CARS

(*Continued from page 83*)

tions desirable were reduction of shock-absorber control and application of softer rubber disks in the lateral-control arms to provide a lower lateral frequency.

During test runs, readings were taken by means of scratch gages to determine deflections of all rubber parts and springs. From previously obtained load-deflection curves of each of these units, maximum loads were determined for all principal elements of the truck. Some of the runs were made at high speeds on a very rough secondary freight road, and a few of the scratch-gage recordings showed lateral loads at the journal equal to the vertical load on the journal. It was feared by some railroad engineers that the coil-spring truck with no center plate or side bearings might be subject to "nosing," that is, wandering continuously from one side of the track to the other as permitted by the necessary flange clearance and lateral rail flexure. However, no tendency to nose has ever been observed on either the single trucks or the articulated truck of the experimental cars. Both conical and cylindrical treads were tried to see if this action would occur.

The high location of some of the truck parts and access doors in the body made it possible to make changes during runs. Shock absorbers have been revalved, connected, and disconnected, and the lateral control has been adjusted while the train was traveling at ninety miles per hour. Due to the close access, no danger was involved in such work.

Cathode-ray-oscilloscope observations were made of the high-frequency vibrations throughout the truck suspension system at a variety of speeds. A very high value is now placed on the use of rubber in some parts of the truck, as a result of these studies.

To record lateral shocks transmitted to the car body, a very simple and crude accelerometer was used. Small hardwood blocks, "tumble blocks," were carefully calibrated for tipover value on an inclined plane and were matched in two sets of three blocks each. During most of the test runs, one set of these blocks was operated in either of the two experimental cars and the other was operated in one of the standard cars in the test train. The surfaces on which the blocks were mounted were carefully leveled for each setup. The test cars consistently showed fewer "tumbles" than did any of several standard-type cars used on various test runs. A typical record is given in Table 1.

TABLE 1

NUMBER OF FALLS RECORDED ON A RUN OF 85 MILES AT AN AVERAGE SPEED OF 61 M.P.H.

Lateral acceleration (per cent of gravity)	9	12.6	19
Test car A-22	170	20	0
Modern standard car	582	54	4

The degree of accuracy of the tumble-block records is indicated by a close correlation with data taken from an entirely different source. Deflections of the lateral-control arms of several different magnitudes were recorded for a known mileage. Since the rate of this unit was known, these deflections were converted to forces, and thus force expressed as a percentage of the body weight was plotted against number of occurrences per mile. This curve agreed closely with the results of the tumble blocks.

Despite their extreme light weight, these cars in road tests, at speeds up to one hundred miles per hour, demonstrated outstandingly better riding qualities than older, heavyweight equipment and modern, lightweight coaches utilizing conventional trucks. The demonstrations have verified conclusively the prediction of theory, that heavy equipment is not necessary for good riding. Static deflection of the spring system, whatever the car weight may be, determines the transmissibility of the system, and ultimately the comfort of the passengers within.

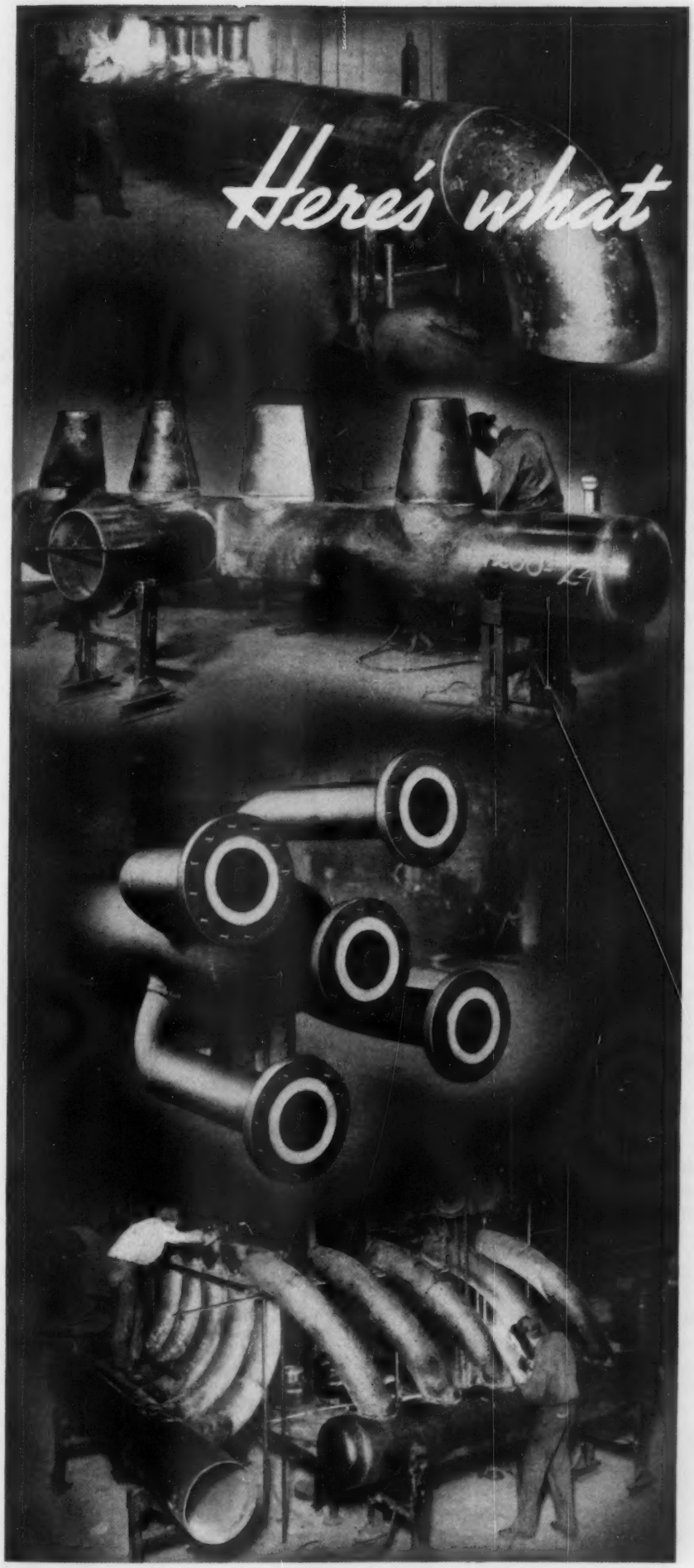
Experimental Truck Performance Satisfactory

The successful performances of the experimental trucks indicate that the journal springs for service trucks should also be relatively stiff. If a truck is to be sufficiently stable against rolling due to unbalanced side forces, the journal springs, being very low, cannot be sufficiently soft to permit a fundamentally low frequency for the truck frame; therefore, for each truck frame, natural frequency is to be high and is to be safely above the highest imposed vibration encountered in service. The one and three-quarters-inch static deflection chosen for coil-type journal springs gives the following natural frequencies of the truck frame vibrating as a unit: Vertical, six cycles per second; lateral, seven cycles per second; pitching, 14 cycles per second. At a speed of 120 miles per hour, a wheel encounters 33-foot rail joints at an interval of 5.34 every second. Since even the fastest schedules do not permit operation at this speed, there is little likelihood of truck-frame vibration being troublesome.

The coil springs mounted just above the journal box are so applied that some lateral movement can take place between the journal box and the truck frame. This lateral movement is permitted by rubber and steel vulcanized pads on the side of the pedestals which are deflected in compression to relieve lateral shocks. The arrangement of parts is different from that used on the experimental cars, but the characteristics are the same. Truck frames are arc-welded of high-tensile low-alloy steel and are stress-relieved before machining.

The greater weight of the production cars necessitated the use of eight body springs per truck. These springs are mounted just above the frame side members and extend upward within the body to the body-support structure. The static deflection of ten inches, together with the rubber insulator at the top of the spring with a deflection of three-eighths inch, provide highly satisfactory isolation of the body from disturbances in the truck. As was done for the experimental car springs, considerable analytical and test work was performed to establish correct relationships between static deflection, working height, and pitch diameter to obtain freedom of lateral movement and stability. In these springs, the greatest lateral movement encountered in normal service increases the working stress near the ends of the coil by twenty-five per cent.

The lateral springs used in production cars are two plates clamped rigidly to the side of the truck frame extending between the body-support bulkheads to a point above the center of gravity of the body. Lateral tie rods with rubber-mounted end connections attach the lateral spring to the car body at a point about twenty inches above the center of gravity of the entire body assembly.



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WHAT IS THE MATTER WITH THE RAILROADS?

(*Continued from page 79*)

Mr. Joseph B. Eastman, former Coördinator of Transportation, attempted a study of these transportation agencies with a view to determining to what extent they have received public aid. The purpose of this study was to clarify the facts and the hope was that it would lead to identifying the economic fields in which each type of transport belonged. His report concluded that for the seventeen-year period (1921–1937) highway costs have aggregated 25½ billion dollars, of which the highway user has paid 10½ billions and the general taxpayer the remaining 15 billions. Yet we are staggered at the seven billion dollars Mr. Roosevelt says the public must furnish to finance its own defense.

Wherever there are duplicate facilities, there is duplicate service, and therefore a competitive struggle for the same traffic. There should be a coördination of all of these agencies, but when some of the major transportation fields are heavily subsidized by the Government while others are not, how can there be any basis for stable coördination? There is every indication that the Government intends to continue to promote highway transport and not to promote railroad transport.

Obviously, economic justification of any project requires that it shall pay its way out of earnings. Government promotion requires that the project is paid for partly out of taxes. The former is developed and sustained on the basis of its earning power, the latter on the basis of the taxing power.

In this thesis we are examining existing conditions. It does not help to review ancient history of this or that railroad. Doubtless all had their faults. What business is free from them today? There are individual cases of poor management, duplicate facilities and other faults still existing. Since 1920, however, the approval of the Interstate Commerce Commission has been required for all extensions and abandonments as well as for all railroad security issues.

When discussing the subject of what is the matter with the railroads as a whole, I have avoided the plight of individual railroads brought about by their own faults or otherwise and have focussed attention upon the major conditions which, in recent years, have brought about the present plight in the entire railroad transportation industry.

There are three major "monkey wrenches" cluttering the wheels of the railroad industry at present. One of them is government control through the Interstate Commerce Commission; another is labor control; and the third is the willingness of the public to permit through legislation heavier motor trucks on our existing highways and to subsidize motor truck, water and air transportation, while the railroad industry (which the public owns although it does not seem to realize it) is required to compete against these government subsidized competitors.

The congressional acts to regulate the railroads almost invariably have had for their purpose increased safety and guarding of the public interests against railroad monopoly. The Interstate Commerce Commission has acted as the watch-dog in this respect. The Motor Carriers Act of 1935, however, had for one of its main purposes the protection of the motor carrier industry. It aimed at seeing that the motor carriers received compensatory tariffs; it encouraged legitimate motor transport on highways by putting the cut-rate trucker out of business. The inherent characteristic of railroad laws in guarding the public against railroad monopolies coupled with the encouraging characteristic of the Motor Carriers Act toward motor carriers, gives a great advantage to the latter because these forces are diametrically opposite. One emphasizes restraint; the other, encouragement.

Labor control on the railroads has been extensive for many years. It has developed attractive working conditions and, in some cases, unwarranted wages. The average hourly earnings of railroad employees today are two and one-half times what they were twenty-five years ago; they amount to an average of 75 cents an hour. It is not uncommon for a train conductor to be paid $3000 to $3500 per year for 200 days of actual work averaging about nine hours a working day. Under modern railroading the train conductor is little more than a ticket-taker and his duties do not require heavy mental strain. In addition, the so-called "feather-bed" compensation paid for time not actually worked is one of the large items of railroad transportation expense.

Railroad tariffs are no longer fixed by fair rate of return on capital. They are fixed by the competition of other transportation agencies. Consequently, the railroads are at a great disadvantage compared with their competitor because they pay higher wages and have more attractive working conditions. Railroad labor is now recognizing that subsidization of their highway and waterway competitors is the fundamental cause of many of them losing their jobs. The reduction of train service on many of the railroad branch lines, and even on main lines, has taken away jobs from thousands of railroad employees. That which is harmful to the employer is harmful also to the employee.

Here is one of the major industries of the country, the railroads, in which a third of its property is in the hands of receivers or has but recently been "through the mill"; a third is heading for receivership or voluntary reorganization; and a third will probably be able to weather conditions a while longer. This is a sad picture. We wonder who it is that owns this large amount of non-productive capital; about 21 billions in all and 14 billions of which are in trouble? The answer is this: M. I. T., Harvard University, the Massachusetts General Hospital and almost every other educational and charitable institution in the country have invested part of their funds in railroad bonds. The funds of your life insurance company and your savings bank are heavily invested in railroads. Insurance companies, banks, educational institutions and foundations own about 56 per cent of the bonds of the United States railroads. It would seem obvious, therefore, that you and I are personally interested in the welfare of these railroads.

In this matter of transportation the average engineer is influenced altogether too readily by what he reads. Our reading today is much crowded with propaganda. There is a lot of clever misstatement or partial statement of facts, and a subtle leading of the mind to erroneous analysis and to false conclusions. It is a fair criticism of the average intelligent man of today that he reads too much and thinks too little. There is nothing about the plight of the railroads which cannot be understood by any intelligent person. Up to the present time there has been too much misrepresentation of the facts and an overabundance of illogical thinking. So much of all this has appeared in print that the public

is bewildered and is inclined to be led by the cleverest editors.

The situation is so intolerable that sooner or later the public and legislatures will have to do something about it. There has been a lot of talk on the subject but up to the present time nothing constructive has been done. Engineers and economists must give serious consideration to this problem. Unless the trend of government subsidy is stopped, more railroads will be driven into receivership and the whole railroad industry will find itself government owned.

It is self evident that agencies in the same field, seeking the same transportation, and doing the same transportation job, should shoulder like responsibilities to the extent that if the Government regulates the railroads, competing agencies should also be regulated. If the railroads' competitors are to be subsidized, the railroads should enjoy the same privilege. If wages, hours and working conditions are to be determined for the railroad employees by the Government, they should be so determined for its competitors on the same standards. Railroads are properly asking for equality in safety, in labor and tariff regulations, in taxation and in subsidy.

This nation can ill afford to lose its railroads or to allow them to become run down; they are absolutely necessary to our national defense and for the economic life of the country. The apathy of the public toward the railroads is difficult to understand. The root of this indifference probably lies in the lack of realization as to whose "ox is being gored."

RAILROADS IN MINIATURE

(*Continued from page 78*)

neer. At yard and terminal points a "yard board" is bridged with the engineer cabs, and through circuit keys, the yardmaster can cut out the "cabs," and make yard movements independently of the road engineer.

Terminal, junction and intermediate switching points have definite interlocking territories in which the movement of trains is under the direct control of the towerman at those respective points. All signal towers are on the dispatcher's telephone line so that train movements may be called through to the next tower, orders received, and reports given to the dispatcher. Between interlocking territories, the main and branch line is protected by automatic signals. On all automatic signals, and the home signals at interlocking points, a track relay is connected in the third rail circuit so that trains are brought to a standstill on a STOP indication.

The interlocking machines at the signal towers are a double bank of multiple contact rotary switches, one bank controlling switch point movements, and the other signal indication. The wiring is a simple series route circuit. When a route is set up, the only signal which can be cleared is that one at either end of the route, depending on the direction of traffic. Through this series circuit, no conflicting routes can be set up. The signal levers control relays which in turn operate the wayside signal indications, also signal lamp repeaters on the master indicator board of the system by which the road engineers are advised as to the handling of their trains. Locks, unlocks, and traction circuit breaks are installed on all towers having control over movable bridges which give visitors access to the various points around the system.

Space does not permit a detailed description on this phase, due to the great variety of items possible. It

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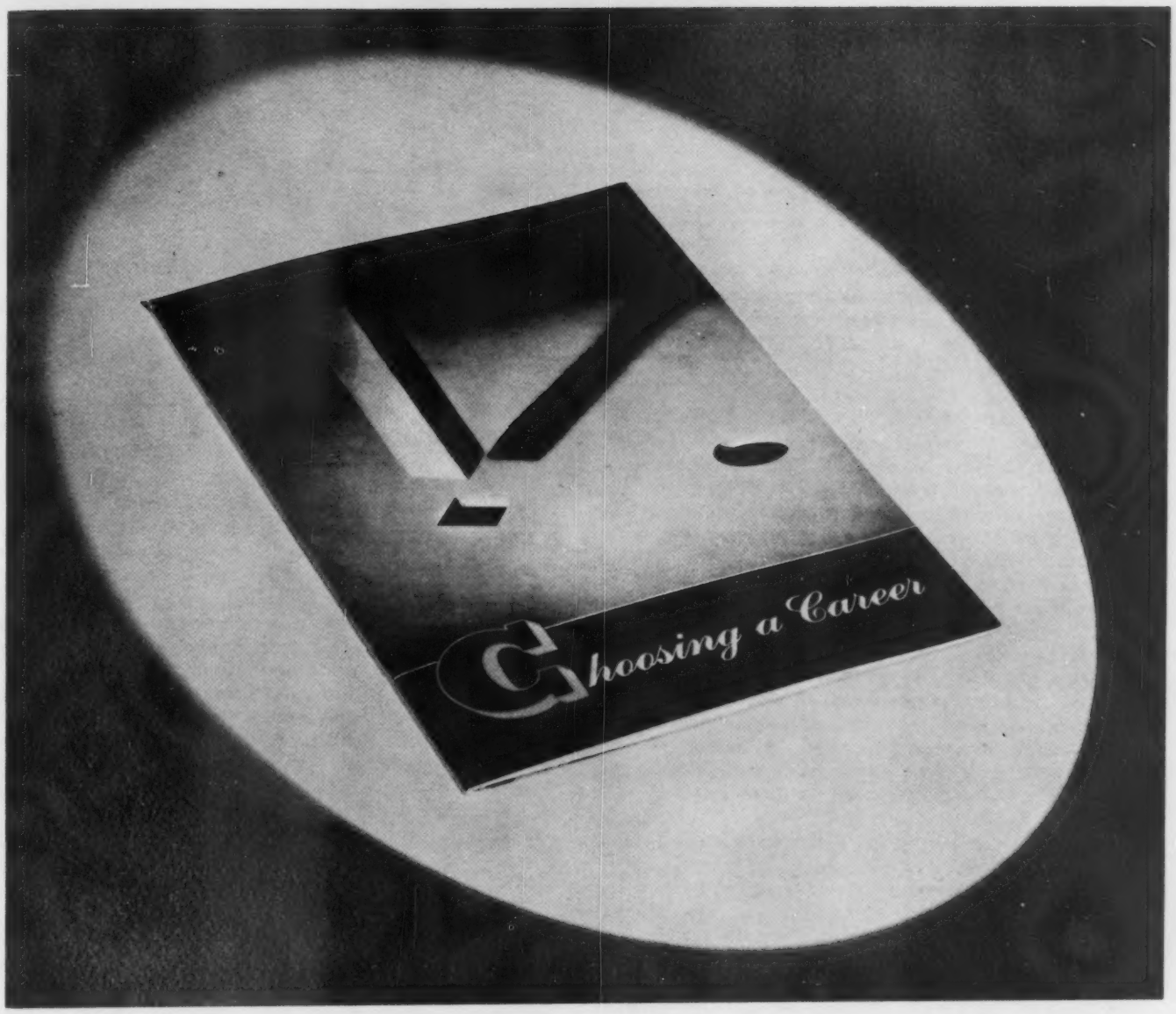
might be said that the basis of all scale model building is the selection of the prototype to be modeled. The newcomer in this hobby will best be served if he assembles his first model from a commercial kit. He will thus learn the fundamental parts of the model, and so will acquire the skill to build anything he wants from plans available. Materials will vary with the individual's familiarity. We have seen A-1 models built with every conceivable material — from paper — to metal — to plastics, all faithfully reproducing the desired detail. All that is required and really needed is a little thought and a little patience.

The projected scenery plans underwent considerable revision after the track work was finished. This was due to a change in ideas as to the types of communities served by the railroad. The rolling hills, ravines, cuts and fills were built up on rough framing covered with half inch wire mesh over which a mixture of asbestos boiler lagging and finish plaster was modeled to suit the terrain. Trees of sponge and steel wool dyed were scattered as needed. Buildings were built up from kits, or any suitable available material to conform with the plan. We wish to call attention to the model of the Pelham Manor station illustrated herewith. This model was constructed from the same materials as its prototype. Westchester granite was cut into scale sized blocks and set in mortar, and the framing according to the architect's plans. The roof is to be made of scale model Spanish tile — a problem which is still unsolved.

With the completion of the railroad to the point where practical operation was possible, the most interesting part of model railroading was available to all. Regardless of one's skill in the crafts, we can all fit into an operating group. First, by common consent, a trainmaster was selected, under whose direction all train movements are made. A list of the necessary operating jobs was made, and members were permitted to bid for the different posts. This procedure is now followed every six months. As the line has been operating for a long enough period to insist on real qualifications, the bidding is really spirited, the successful bidder being determined sometimes only by the number of demerits he has, as compared with his opponent.

Operation is conducted under the Standard Code of Operating Rules of the Association of American Railroads and revised to meet model railroad conditions. We also operate under the "brownie" system of merits and demerits. A schedule of "brownies" is posted covering all infractions of operating regulations and rules. They are handed out by the trainmaster at the end of each operating period. The accumulation of too many "brownies" makes a member ineligible to operate until they are removed in the prescribed manner.

The present set-up of facilities requires a minimum of twenty-three operators to run the road. The operating nights are so arranged that they will not place too great a burden on the member's time. The first and third Fridays of each month were selected with this thought in mind, and also to assure ourselves of a full operating crew. For advertising purposes and the creation of good-will, the premises are open to visitors on operating nights free of charge, and it is unusual when there is not a capacity crowd, so widespread is the interest in the hobby.



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(*Continued from page 85*)

cool for two minutes before being moved forward for the trimming and normalizing processes.

In order to finish the rail for service the ridge of upset metal must be removed from the ball and edges of the base of the rail. This is accomplished in part at the next work station where an oxy-acetylene cutting blowpipe, guided on a small mechanical fixture, is used to remove most of the upset metal. These oxy-acetylene cuts are made while the next weld is in progress, after which the rail is moved to the next work position where normalizing takes place.

Normalizing is employed for the purpose of refining the grain structure of the metal in the vicinity of the welded area that has been affected by the welding. In this operation no pressure is used, but heating heads, similar in shape no those used in the welding operation, are lighted and oscillated over the heat affected zone (Figure 3). This area is uniformly reheated to a temperature above the critical point and then allowed to cool in the atmosphere.

A weld in 112-pound section rail requires about eight minutes while the trimming and normalizing operations together require about the same time. Most jobs, therefore, are set up so that the operator performs both the trimming and normalizing operations in order that the work may move steadily along the production line. Flexible-shaft grinders are then used to smooth off the top surface and the side surfaces of the ball, and the sides of the base (Figure 4). In this type of set-up, with one welding machine, the average number of joints made in a working day is approximately twenty-five.

In order to carry on the welding of rails by this method a crew of approximately ten men is required, none of whom, other than the welding and normalizing machine operators, need special training.

Figure 3. Normalizing refines the grain structure of the metal in the vicinity of the weld

Tests and Performance

Laboratory tests of the pressure welds have been thorough and extensive. In metallographic and mechanical tests, welds made in 112-pound and 131-pound section rails by pressure welding show remarkably high quality. For example, a tensile strength of 137,000 pounds per square inch was attained in samples taken from the weld zone of pressure-welded rail. Similar samples taken from unwelded rail reached a tensile strength of 133,000 pounds per square inch. Elongation of eight per cent was attained from the weld metal in comparison with an elongation of 7.6 per cent in the base metal of the rail. Endurance tests also showed up satisfactorily, and field reports indicate confirmation of laboratory findings.

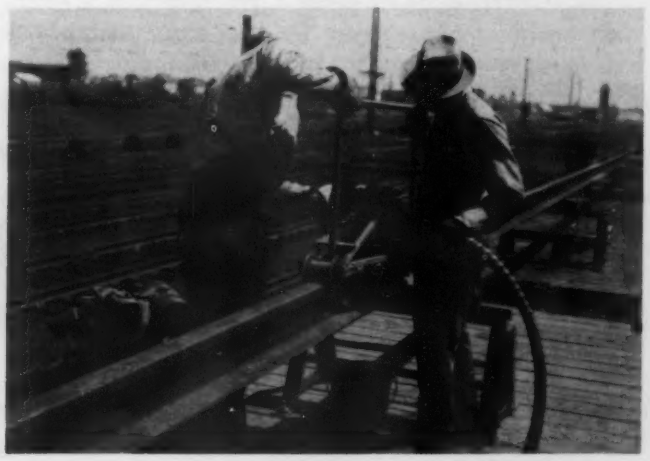
Expansion

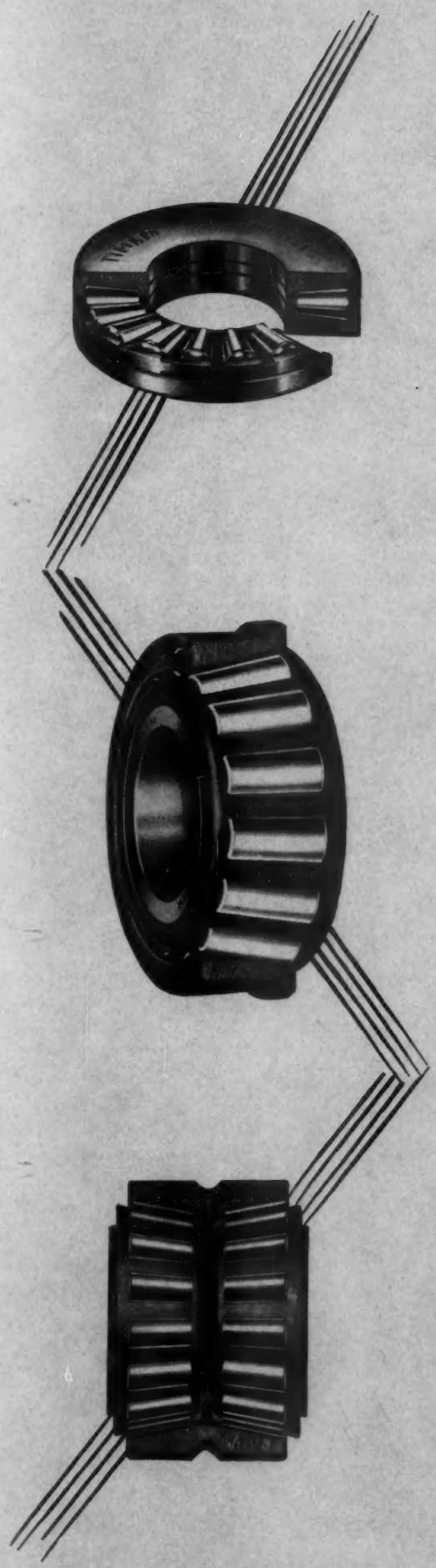
Provision must be made for expansion and contraction of welded rails. However, when long rails are used in highway crossings they are generally partially covered, embedded in the paving or otherwise protected so that temperature changes are not extreme. Long stretches of welded rail present no unusual problem if sufficient anchorage is used, together with double shoulder tie plates.

Results

After using this method of pressure welding rails over a period of three welding years, the results have come fully up to our expectations, and it is far superior to our former method of hand welding or of using joint bars within the limits of highway grade crossings.

Figure 4. Flexible shaft grinders are used to finish the top and sides of the ball of the rail after welding





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G-E Campus News

JUNGLE JIVE

MISSIONARIES working among a newly discovered tribe of savages in Netherlands New Guinea, which has many times been called one of the "earth's remotest spots," had a strange experience.

They invited natives into their bamboo hut and turned on their short-wave radio. The tribesmen looked at one another in frightened amazement. Rev. C. Russell Deibler, one of the missionaries, says this of what happened: "As they heard voices coming from the receiver, they crouched over close and jabbered back, utterly bewildered where the strange voice was coming from."

The missionaries wrote their experience in a letter to Station KGEI, G.E.'s short-wave station in San Francisco, which sends its radio signal into Asia, using special directional antennas.

PRESTO!

THREE tiny 1000-watt mercury lamps, mounted in the new television floodlight developed by G-E laboratory engineers, yield as much light as 225 ordinary 60-watt bulbs. For the same amount of illumination these powerful little lights produce only one-fourth as much heat as do incandescent lamps. Water cooling dissipates much of the heat and so makes possible the very small size.

The new lights are equipped with motors and gears for remote control, so that they can follow the movements of studio performers.

These tiny lamps were developed at G.E.'s Lamp Department at Nela Park, Cleveland, which each year selects promising young engineering-college graduates from "Test" to train them in the lighting game.

SPIDERCRAFT

COULD you spot-weld wire one quarter as thick as a human hair?

That's the problem G-E engineers faced in producing filaments for thermocouples, those little super-sensitive devices used in measuring high-frequency alternating currents or voltages. These dainty filaments are 1/2000 of an inch in diameter —so small that they are almost invisible—and have to be welded into a "K" shape.

The work is so fine that it must be done under a microscope, using a pair of tweezers to hold the wires.

At Schenectady there's a whole section of the G-E Industrial Department devoted entirely to welding. Practically all the men in this section are graduates of the G-E Test Course. General Electric Company, Schenectady, N. Y.

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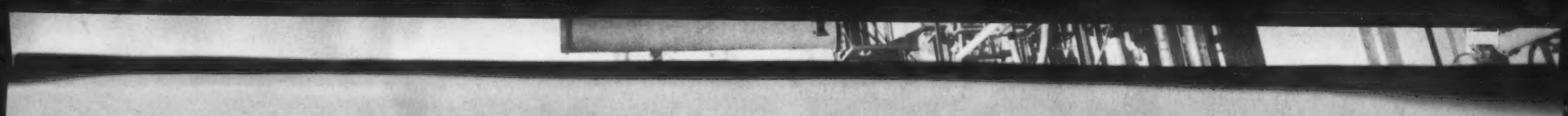
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